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REGIONAL TEMPERATURE REPORTING NETWORK 1968 FIELD RECONNAISSANCE SURVEY. A FUNCTION OF THE COLUMBIA RIVER THERMAL EFFECTS STUDY

William Schmidt, et al

Federal Water Pollution Control Administration
Portland, Oregon

February 1969

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US DEPARTMENT OF THE INTERIOR

REGIONAL TEMPERATURE REPORTING NETWORK

1968 FIELD RECONNAISSANCE SURVEY

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REGIONAL TEMPERATURE REPORTING NETWORK

1968 FIELD RECONNAISSANCE SURVEY

A Function of the Columbia River Thermal Effects Study

Prepared by

William Schmidt, Robert Cleary

Details of illustrations in this document may be better studied on microfiche.

Working Paper No. 62

United States Department of the Interior
Federal Water Pollution Control Administration
Northwest Region, 501 Pittock Block, Portland, Oregon 97205

February 1969

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INTRODUCTION

Reliable water temperature records are essential to the development of an effective water temperature management program. Preliminary organization of a regional temperature reporting network (RTRN) to provide these records for the Columbia and Snake Rivers has been completed. These records will function as the data source for evaluating and predicting the impact of hydroelectric, thermal electric power developments, and other thermal waste sources upon water temperatures, and for monitoring changes in water temperature relative to established water quality standards criteria. Continuously recorded, accurate temperature data at each hydroelectric project, above and below each major tributary, and at other points of special interest on the Columbia and Snake Rivers will be provided by the RTRN.

The FWPCA Northwest Regional Office has the responsibility for organization and development of the RTRN as one of the stated functions of The Columbia River Thermal Effects Study. Installation of thermographs will be completed by July 1970. Data compiled during this development period will be available to all interested agencies through the FWPCA STORET system. Arrangements will be made for publication of selected records in the USGS Weekly Runoff Reports.

In March 1968 the needs and suggestions of fifteen state and federal agencies were requested and incorporated into the organization of the RTRN. Representatives from these agencies met in June 1968 to consider and recommend thermograph locations needed for a complete temperature network. Preliminary conclusions of this group included recommendations for "minimum" and "comprehensive" lists of thermograph stations along the main stem of the Columbia and Snake Rivers and their tributaries. The "minimum" list includes primarily those stations necessary for supplying input data for water temperature evaluation and prediction programs plus several locations essential to the water quality standards surveillance program. The "comprehensive" list includes essentially all temperature prediction programs and water quality surveillance, plus eight stations of special interest to the fisheries objectives. Figure 1 shows all recommended RTRN thermograph locations. Also shown are locations where temperatures were being taken or recorded at the time of the field survey.

Overall accuracy requirements for instrumentation in the network specified error limits of ± 0.5 °C including an instrument error not to exceed ± 0.2 °C. Overall accuracy is determined by errors inherent in the instrument, plus errors due to representation of average river cross-sectional temperatures by measurements at single points.

It was apparent from the RTRN preliminary organization efforts that extensive field reconnaissance surveys would be prerequisite to implementation of the proposed network program. The reconnaissance surveys were needed for the following kinds of information:

(1) Recommendations for specific location of individual RTRN sensors and recorders (eg: highway bridge, dam tailrace, USGS gaging station, etc.)

(2) Descriptions of existing temperature measurement devices including recommendations on the suitability of these devices for RTRN purposes.

2b

FIG. 1A COMPREHENSIVE MAP

Regional Temperature Reporting Network Thermograph Sites

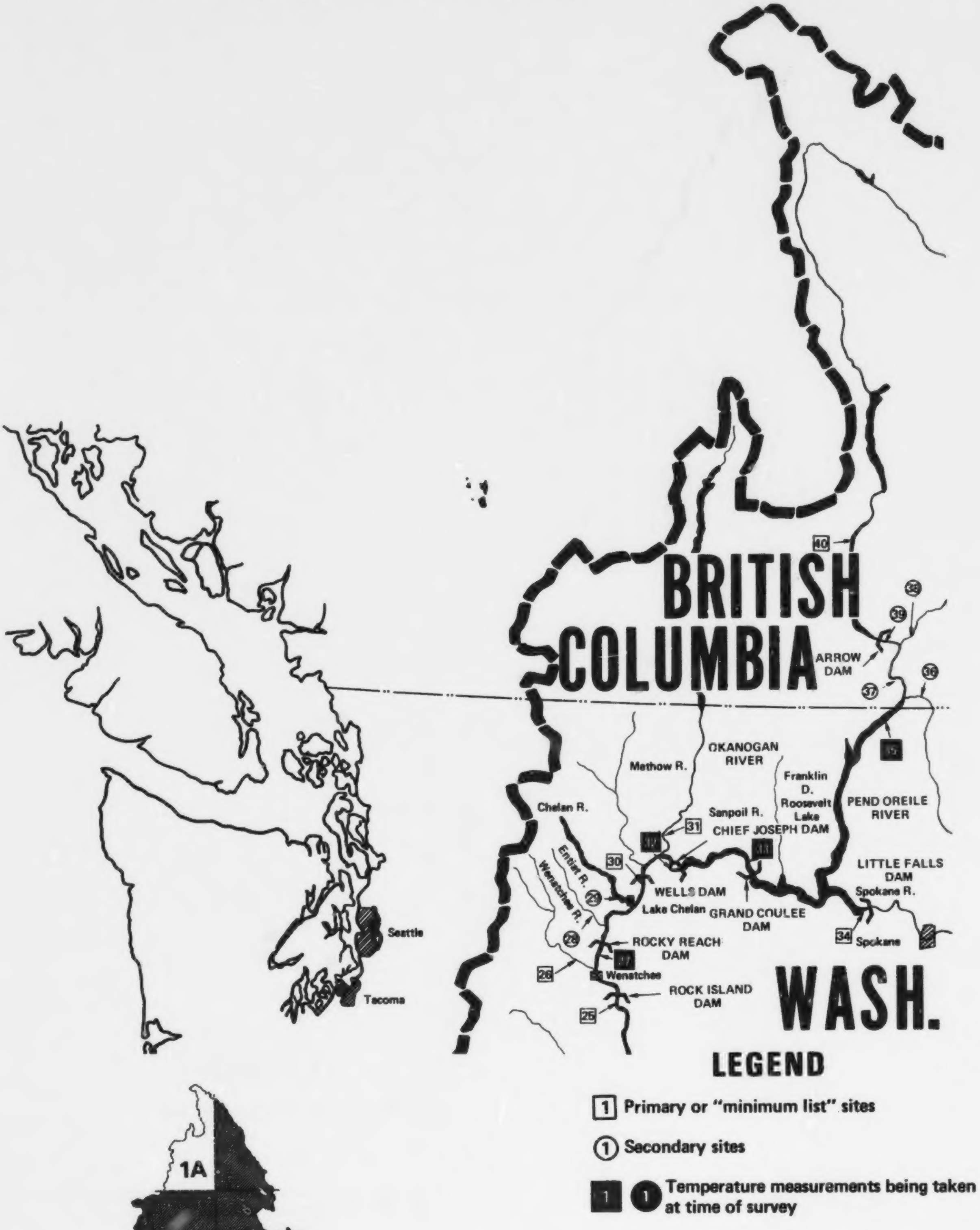
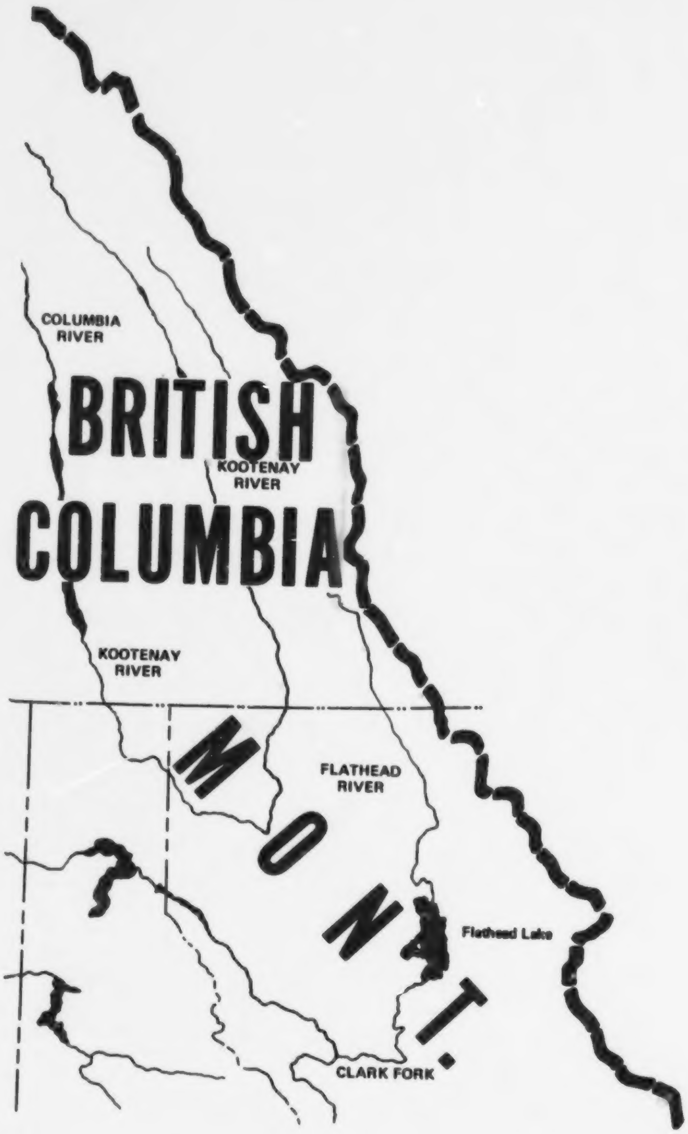

BRITISH COLUMBIA
WASH.
40
38
39
ARROW DAM
37
36
OKANOGAN RIVER
Methow R.
Franklin D. Roosevelt Lake
PEND OREILE RIVER
Chelan R.
Sanpoil R.
31
CHIEF JOSEPH DAM
30
Entiat R.
Wenatchee R.
29
WELLS DAM
Lake Chelan
GRAND COULEE DAM
LITTLE FALLS DAM
Spokane R.
34
Spokane
28
ROCKY REACH DAM
26
Wenatchee
ROCK ISLAND DAM
25
Seattle
Tacoma
1A
LEGEND
1 Primary or "minimum list" sites
1 Secondary sites
1 1 Temperature measurements being taken at time of survey

FIG. 1B

2C

COMPREHENSIVE MAP
Regional Temperature Reporting Network Thermograph Sites


COLUMBIA RIVER
BRITISH COLUMBIA
KOOTENAY RIVER
KOOTENAY RIVER
MONT.
FLATHEAD RIVER
Flathead Lake
CLARK FORK

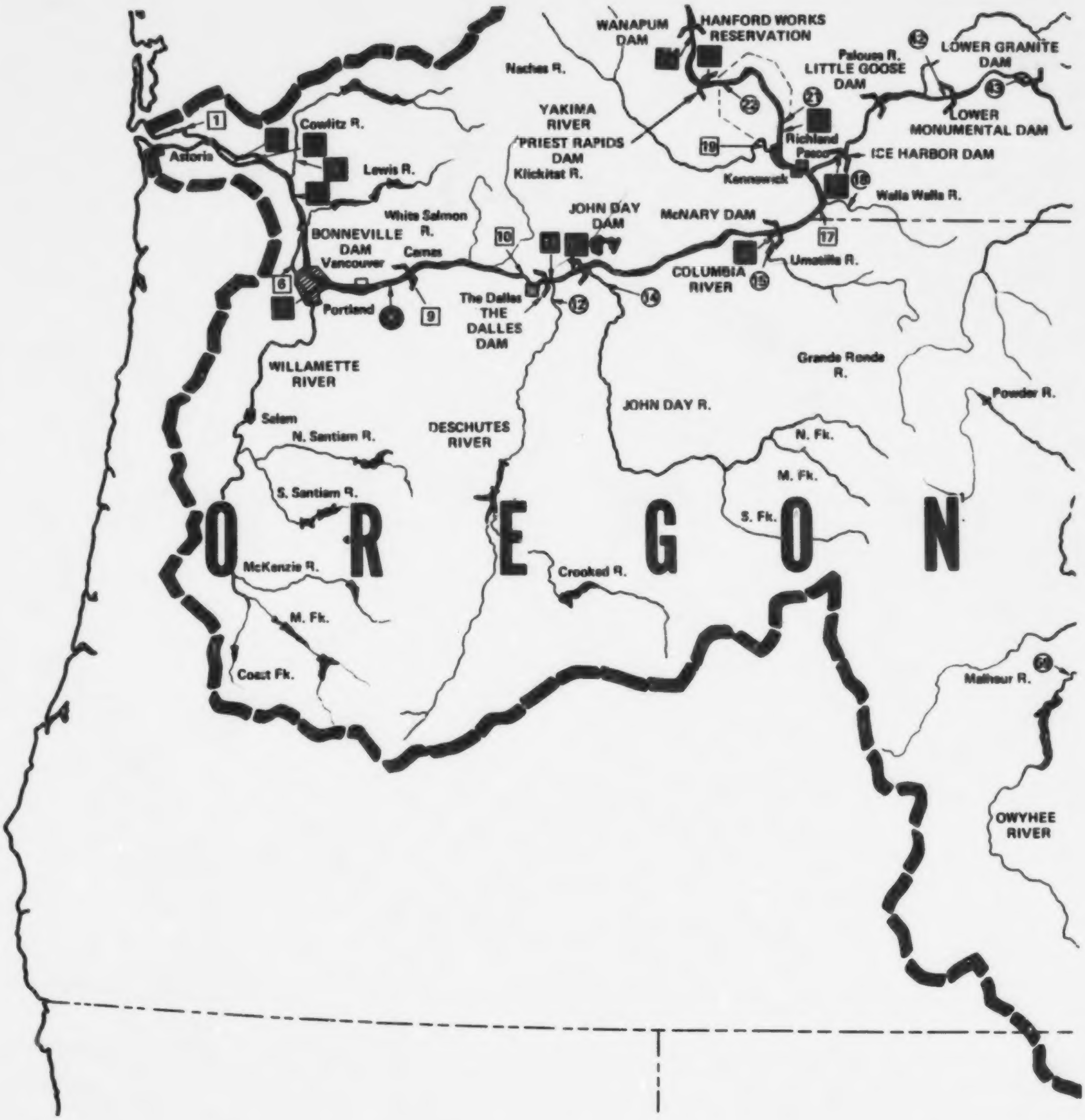
LEGEND

- [1] Primary or "minimum list" sites
- ① Secondary sites
- ■ ● Temperature measurements being taken at time of survey

2 l

FIG. 1C

COMPREHENSIVE MAP
Regional Temperature Reporting Network Thermograph Sites



WANAPUM DAM
HANFORD WORKS RESERVATION
Palouse R.
LOWER GRANITE DAM
LITTLE GOOSE DAM
Naches R.
YAKIMA RIVER
PRIEST RAPIDS DAM
Klickitat R.
LOWER MONUMENTAL DAM
Richland
Pasco
ICE HARBOR DAM
Kennewick
Walla Walla R.
Cowlitz R.
Astoria
Lewis R.
White Salmon R.
BONNEVILLE DAM
Vancouver
Camas
JOHN DAY DAM
McNARY DAM
Umatilla R.
COLUMBIA RIVER
Portland
The Dalles
THE DALLES DAM
WILLAMETTE RIVER
Grande Ronde R.
Powder R.
Salem
JOHN DAY R.
N. Santiam R.
DESCHUTES RIVER
N. Fk.
M. Fk.
S. Santiam R.
S. Fk.
O R E G O N
McKenzie R.
Crooked R.
M. Fk.
Coast Fk.
Malheur R.
OWYHEE RIVER
1
6
9
10
12
14
15
16
17
19
21
22

LEGEND

□1 Primary or "minimum list" sites

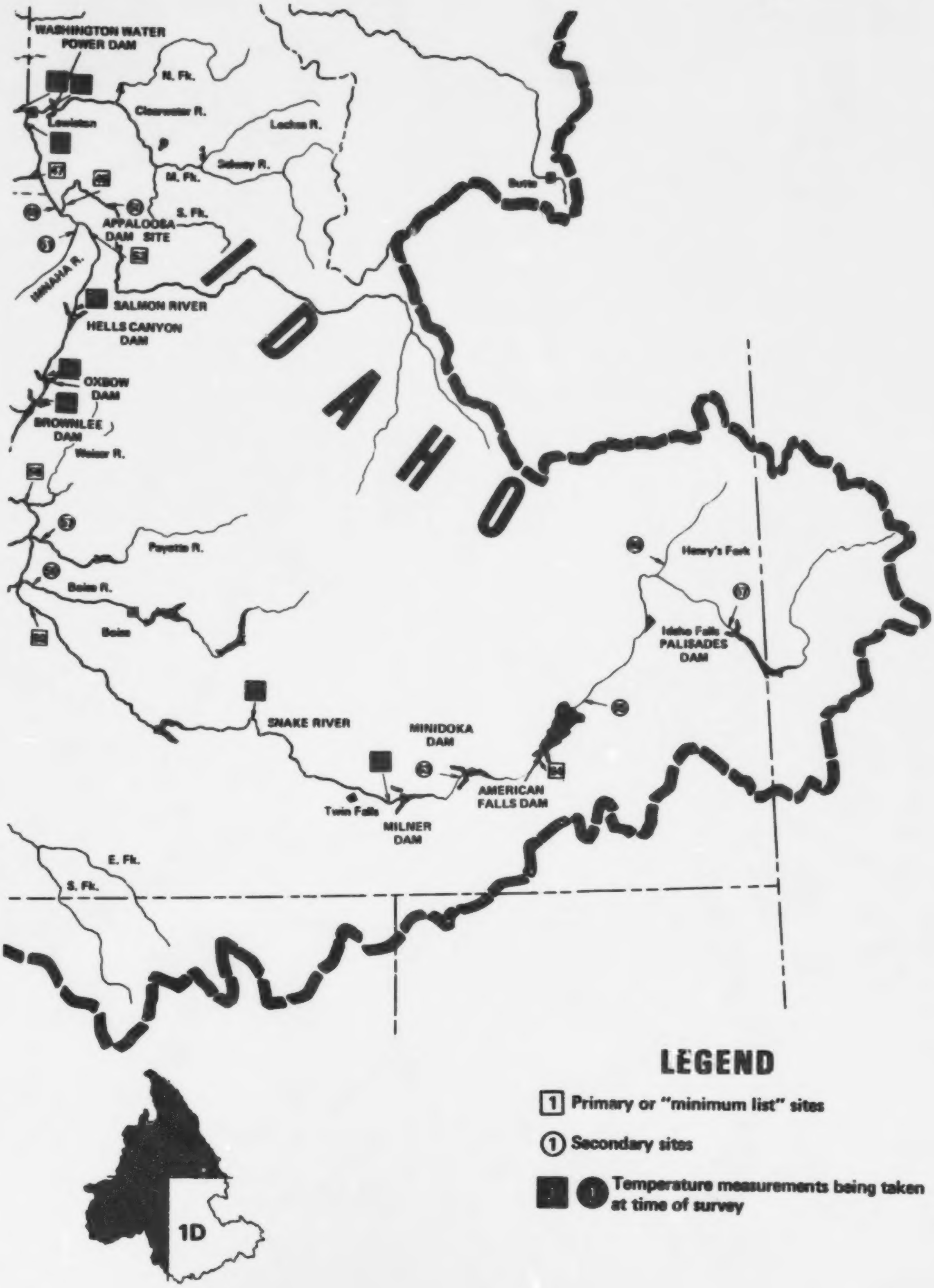
① Secondary sites

■ ● Temperature measurements being taken at time of survey

FIG. 1D

2e

COMPREHENSIVE MAP
Regional Temperature Reporting Network Thermograph Sites


WASHINGTON WATER POWER DAM
N. Fk.
Clearwater R.
Lewiston
Lochsa R.
Selway R.
M. Fk.
S. Fk.
APPALOOSA DAM SITE
IMNAHA R.
SALMON RIVER
HELLS CANYON DAM
OXBOW DAM
BROWNLEE DAM
Weiser R.
Payette R.
Boise R.
Boise
IDAHO
Butte
Henry's Fork
Idaho Falls
PALISADES DAM
SNAKE RIVER
MINIDOKA DAM
AMERICAN FALLS DAM
Twin Falls
MILNER DAM
E. Fk.
S. Fk.
1D
LEGEND
Primary or "minimum list" sites
Secondary sites
Temperature measurements being taken at time of survey

(3) Recommendations on the need for additional field work at individual RTRN thermograph locations in the form of temperature and/or current measurement cross-sections.

(4) Photographs of RTRN sites and existing temperature measurement devices.

Consequently, a two-week reconnaissance survey was conducted in August, 1968. Additional field temperature surveys were conducted in September and October, 1968. The two-week reconnaissance survey included readily accessible "minimum" RTRN list sites plus three additional sites on the "comprehensive" list.

This report documents the results of and the recommendations made, following the reconnaissance and field temperature surveys.

SUMMARY

Potential thermograph sites along the Columbia River from Bonneville Dam to the Canadian Border and the Snake River from the Columbia River confluence to American Falls Dam were investigated during the August 20 to 30, 1968 reconnaissance survey. Temperature cross-sections were taken on September 5th and 6th at some of the critical thermograph sites recommended during the reconnaissance survey. On September 30 and October 1, 1968, temperature cross-sections were taken in the Willamette River below river-mile (R.M) 10.0 and in the Columbia Estuary to determine probable thermograph locations.

The information obtained from the surveys and summarized here is adequate for locating thermographs in the vicinity of the suggested "minimum list" sites and for evaluating existing temperature measuring devices for possible incorporation into the network. Due to time limitations or unsuitable conditions during the reconnaissance survey (discussed in detail in the paragraphs for the individual sites), additional field investigations will be required at several of the sites prior to any thermograph installation.

Table 1 contains a summary tabulation of pertinent information obtained from all the potential thermograph sites described as "minimum list" and sites visited during the surveys. FIGURE 2 is a map showing thermograph sites investigated during the reconnaissance survey. Some "minimum list" stations were not included in the survey: Thermographs on the Columbia River at Richland, Clatskanie, Longview, Prescott, and Vancouver are presently operating satisfactorily and should

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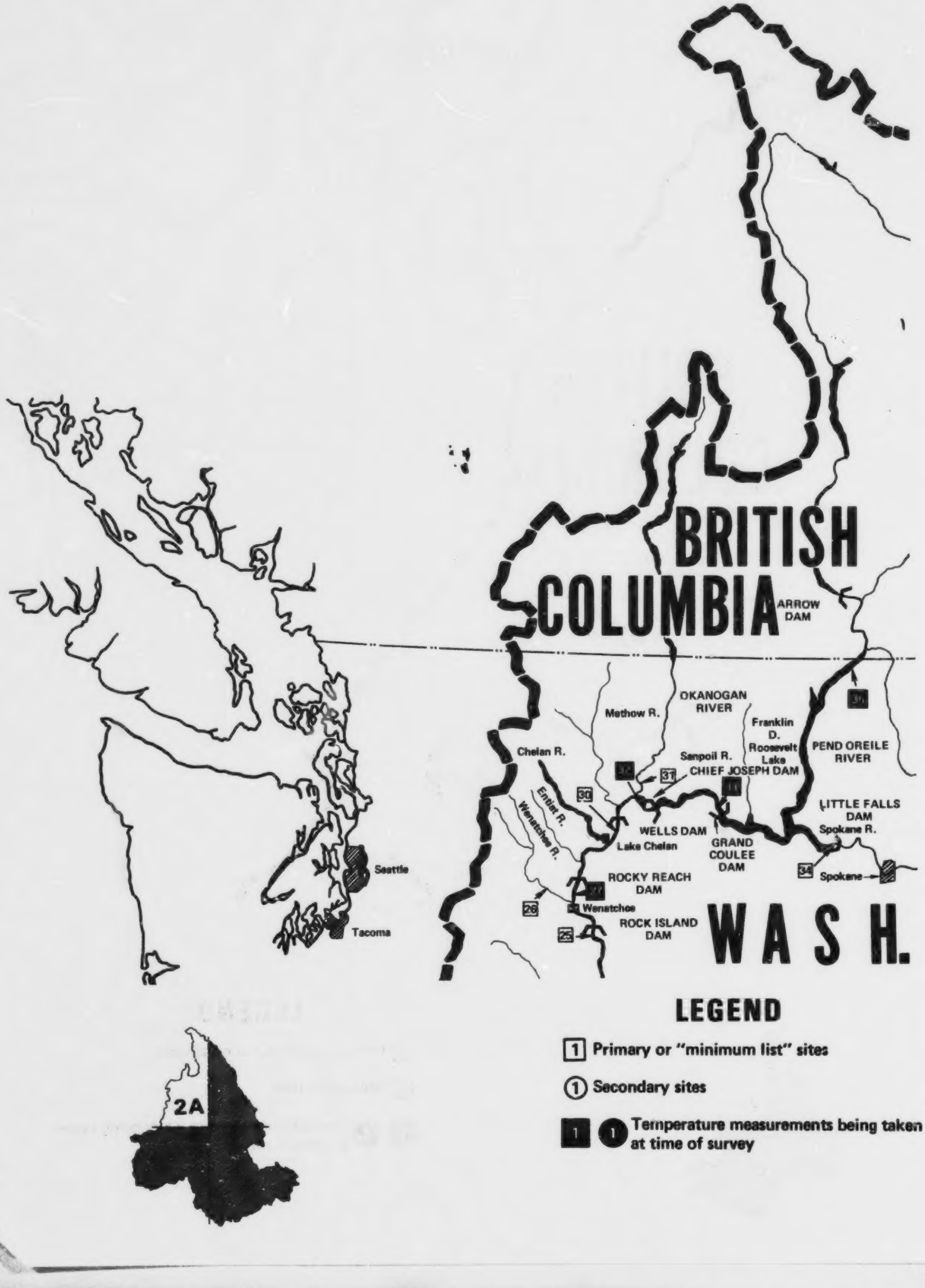
be incorporated into the RTRN. The station at Revelstoke in British Columbia, Canada will not be investigated until suitable arrangements with the Canadian authorities have been completed. Potential sites on the Cowlitz River, at the Lower Monumental and Appaloosa Damsites and the mouth of the Grand Ronde River were not investigated due to time limitations. The sites of Clarkston and Lewiston were eliminated from consideration until the backwater effects from Lower Granite Dam, now under construction, can be determined.

Some of the "comprehensive list" sites were investigated and have been included here (Warrendale and Kettle Falls on the Columbia River) because of favorable locations in the RTRN and because continuous recording thermographs already exist at these sites.

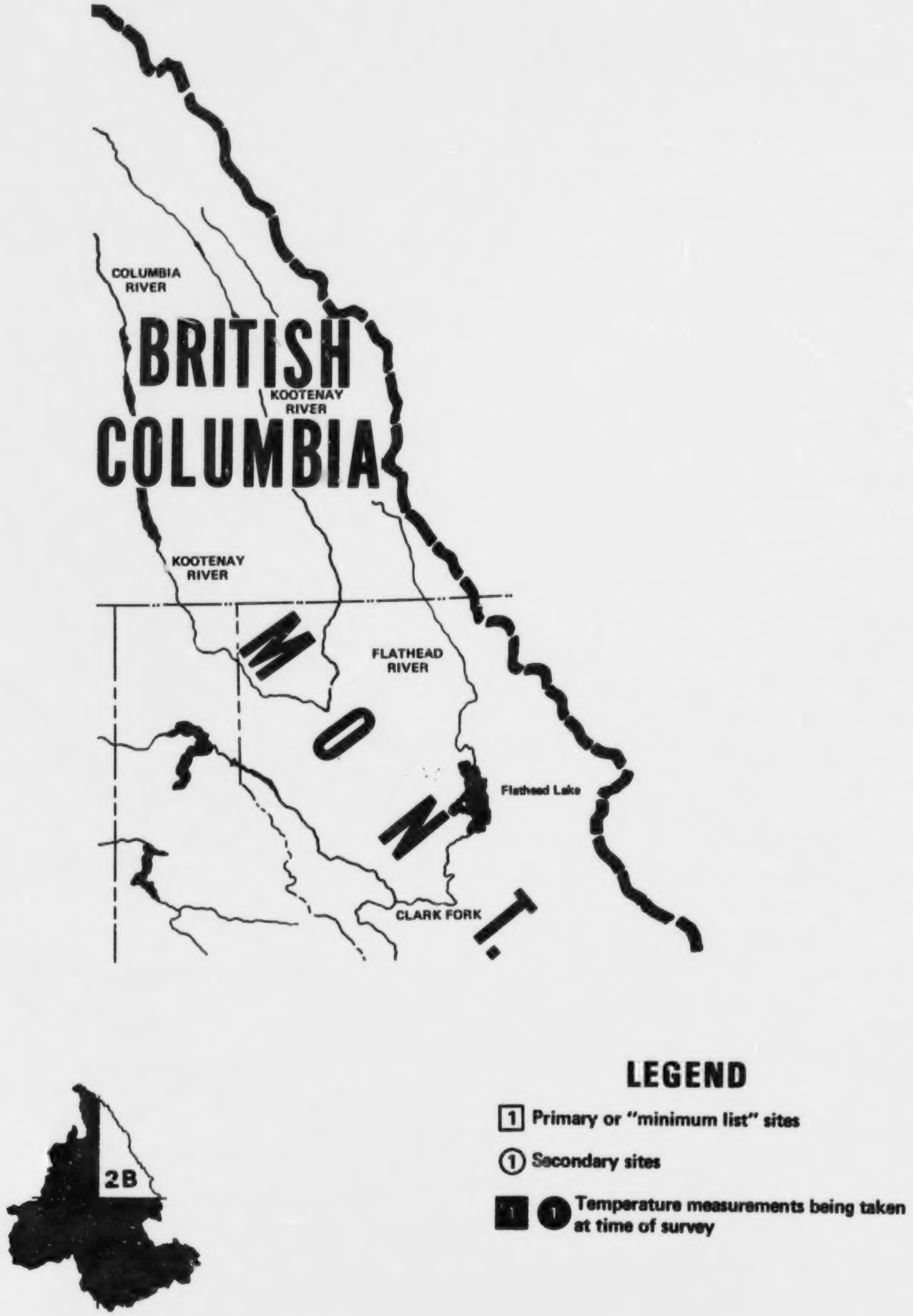
At present the FWPCA has purchased six Foxboro thermographs and six Fischer-Porter thermograph packages. These twelve instruments will be installed at selected locations in the Regional Temperature Reporting Network. In this initial phase it is desired to monitor the main stem of the Columbia River at most of the recommended "minimum list" sites so that ample temperature data will be available as input for the Columbia River mathematical models now being developed.

FIG. 2A 1968 RTRN RECONNISANCE SURVEY SITES


BRITISH
COLUMBIA
ARROW DAM
OKANOGAN RIVER
Methow R.
Franklin D. Roosevelt Lake
PEND OREILE RIVER
Chelan R.
Sanpoil R.
CHIEF JOSEPH DAM
32
31
30
Entiat R.
Wenatchee R.
WELLS DAM
Lake Chelan
GRAND COULEE DAM
LITTLE FALLS DAM
Spokane R.
34
Spokane
ROCKY REACH DAM
27
26
Wenatchee
25
ROCK ISLAND DAM
WASH.
Seattle
Tacoma
2A
LEGEND
1 Primary or "minimum list" sites
① Secondary sites
1 ❶ Temperature measurements being taken at time of survey

6c

FIG. 2B 1968 RTRN RECONNISANCE SURVEY SITES


COLUMBIA RIVER
BRITISH COLUMBIA
KOOTENAY RIVER
KOOTENAY RIVER
MONT.
FLATHEAD RIVER
Flathead Lake
CLARK FORK
2B
LEGEND
1 Primary or "minimum list" sites
① Secondary sites
1 ❶ Temperature measurements being taken at time of survey

6d

FIG. 2C 1968 RTRN RECONNISANCE SURVEY SITES

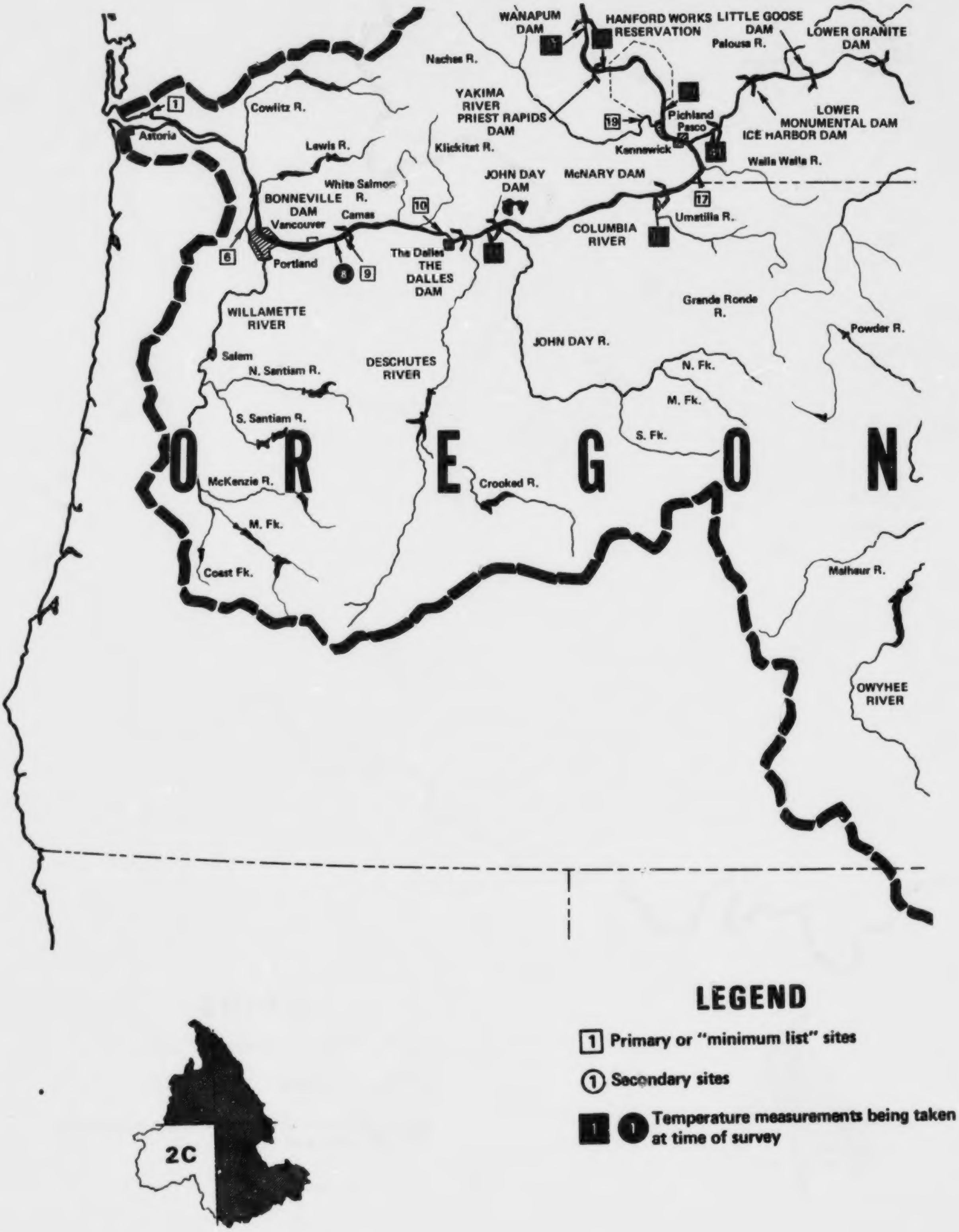

WANAPUM DAM
HANFORD WORKS RESERVATION
LITTLE GOOSE DAM
Palouse R.
LOWER GRANITE DAM
Naches R.
YAKIMA RIVER
PRIEST RAPIDS DAM
Pichland
Pasco
Kennewick
LOWER MONUMENTAL DAM
ICE HARBOR DAM
Walla Walla R.
19
Cowlitz R.
1
Astoria
Lewis R.
Klickitat R.
White Salmon R.
BONNEVILLE DAM
Vancouver
Camas
10
JOHN DAY DAM
McNARY DAM
17
Umatilla R.
COLUMBIA RIVER
6
Portland
8
9
The Dalles
THE DALLES DAM
Grande Ronde R.
Powder R.
WILLAMETTE RIVER
JOHN DAY R.
Salem
N. Santiam R.
DESCHUTES RIVER
N. Fk.
M. Fk.
S. Santiam R.
S. Fk.
O R E G O N
McKenzie R.
Crooked R.
M. Fk.
Coast Fk.
Malheur R.
OWYHEE RIVER
2C
LEGEND
1 Primary or "minimum list" sites
1 Secondary sites
1 1 Temperature measurements being taken at time of survey

FIG. 2D 1968 RTRN RECONNISANCE SURVEY SITES

be

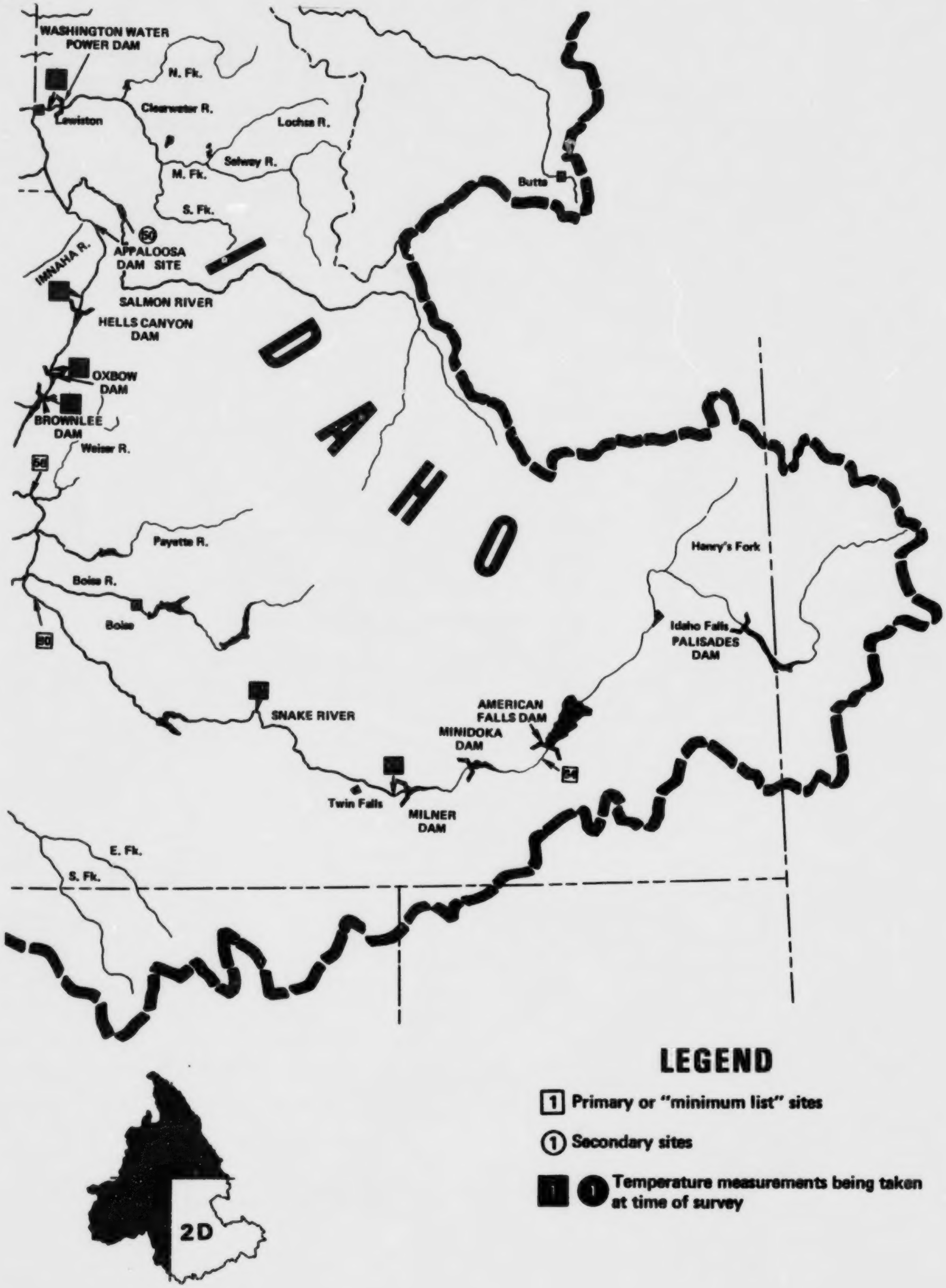

WASHINGTON WATER POWER DAM
N. Fk.
Lewiston
Clearwater R.
Lochsa R.
Selway R.
M. Fk.
S. Fk.
Butte
APPALOOSA DAM SITE
IMNAHA R.
SALMON RIVER
HELLS CANYON DAM
OXBOW DAM
BROWNLEE DAM
Weiser R.
IDAHO
Payette R.
Boise R.
Boise
Henry's Fork
Idaho Falls
PALISADES DAM
AMERICAN FALLS DAM
MINIDOKA DAM
SNAKE RIVER
Twin Falls
MILNER DAM
E. Fk.
S. Fk.
2D
LEGEND
1 Primary or "minimum list" sites
① Secondary sites
Temperature measurements being taken at time of survey

TABLE 1

REGIONAL TEMPERATURE REPORTING NETWORK

MINIMUM LIST SITES AND SITES VISITED DURING THE 1968 SURVEYS

SITE NUMBER (FROM FIGURE 1)	STATION DESCRIPTION	RIVER	RIVER MILE (R.M.)	STATION VISITED DURING 1968 SURVEYS	EXISTING TEMPERATURE SENSING DEVICES DESCRIPTION	/ OWNER	IS DEVICE ADEQUATE FOR RTRN	RIVER CONDITIONS AT STATION DURING 1968 SURVEYS	ADDITIONAL FIELD WORK NECESSARY
1	Harrington Point	Columbia	23.5	yes				Could be fairly well mixed	yes
2	Clatskanie	Columbia	53.8	no	Thermograph	PGE	yes	Well mixed river condition	no
3	Longview	Columbia	66.0	no	Thermograph	PGE	yes	Well mixed river condition	no
4	Cowlitz River (mouth)	Cowlitz	17.3	no	None				yes
5	Prescott	Columbia	75.0	no	Thermograph	PGE	yes	Well mixed river condition	no
6	Swan Island/St. Johns Bridge	Willamette	6.0	yes	Thermograph	FWPCA	no	Year-round temp. x-sect. needed	yes
7	Vancouver	Columbia	106.5	no	Thermograph	U.S.G.S.	yes	Completely mixed river condition	no
8	Warrendale	Columbia	140.8	yes	Thermograph	PGE	yes	Completely mixed river condition	no
9	Bonneville Dam	Columbia	145.5	yes	Thermometer	C of E	no	Tailrace well mixed	no
10	The Dalles Port Commission Dock	Columbia	189.2	yes	None			Well mixed river condition	no
11	The Dalles Dam	Columbia	191.5	yes	Thermometer	C of E	no	Appears well mixed	no
13	Bridge d/s of John Day Dam	Columbia	208.0	yes	Thermograph	AEC	yes	Well mixed river condition	no
13	John Day Dam	Columbia	215.6	yes	U/S Thermos	C of E	no	Dam still under constr. at time	yes
16	Umatilla Bridge	Columbia	290.5	yes	Thermograph	AEC	yes	River well mixed at this point	no
16	McNary Dam	Columbia	292.0	yes	Thermometer	C of E	no	Tailrace is well mixed	no
17	Washington - Oregon Border	Columbia	312.3	yes	None			Fairly well mixed at that time	yes
19	Kiona or Bridge at West Richland	Yakima	*	yes	None			Well mixed @ Kiona maybe @ bridge	yes
20	Pasco	Columbia	329.0	no	Thermograph	AEC	yes	Completely mixed	no
20	Richland	Columbia	338.0	no	Thermograph	AEC	yes	Completely mixed	no
23	D/S of Priest Rapids Dam	Columbia	395.6	yes	Thermograph	AEC	yes	Completely mixed	no
23	Priest Rapids Dam	Columbia	397.1	yes	Thermograph	Grant Co. PUD	possible	Tailrace completely mixed	no
24	Wanapum Dam	Columbia	415.0	yes	Thermograph	Grant Co. PUD	possible	Tailrace completely mixed	yes
25	Rock Island Dam	Columbia	453.4	yes	None			Tailrace and forebay well mixed	no
26	Monitor Washington	Wenatchee	5.8	yes	None			Completely mixed river condition	no
27	Rocky Reach Dam	Columbia	474.5	yes	Thermograph	Chelan Co. PUD	no	Tailrace is completely mixed	no
30	Wells Dam	Columbia	516.6	yes	None			Tailrace is completely mixed	no
31	Monse or Malott, Washington	Okanogan	*	yes	None			Both locations are vert. stratified	yes
32	Chief Joseph Dam	Columbia	545.1	yes	Thermometer	AEC	no	River d/s of dam is well mixed	no
33	Bridge below Grand Coulee Dam	Columbia	596.3	yes	Thermograph	AEC	yes	River d/s of dam is well mixed	no
34	Little Falls Dam	Spokane	30.0	yes	None			Questionable mixed condition	yes
35	Kettle Falls, Washington	Columbia	698.6	yes	Thermograph	AEC	probable	Questionable mixed condition	yes
35	North Port, Washington	Columbia	734.1	yes	Thermograph	AEC	yes	Completely mixed river condition	no
41	Ice Harbor Dam	Snake	9.7	yes	Thermometer	C of E	no	Tailrace well mixed	no
42	Little Goose Dam	Snake	70.3	no	None				yes
44 & 46	Clarkston and Lewston, Idaho	Snake	132.9	no	Thermograph	BCF	no	Future backwater from L. Granite	yes
46	Washington Water Power Dam	Clearwater	4.6	yes	Thermometer	WWP Co.	no	Future backwater from L. Granite	yes
47	Grand Ronde River (mouth)	Grand Ronde	*	no	None				yes
49	Mouth of Salmon River	Salmon	*	no	None				yes
50	White Bird	Salmon	53.5	yes	None			Completely mixed river condition	no
52	Appaloosa Damsite	Snake	213.0	no	None				yes
53	Hells Canyon Dam	Snake	247.0	yes	Thermograph	FWPCA	no	Completely mixed	no
54	Oxbow Dam	Snake	273.0	yes	Thermograph	FWPCA	no	Completely mixed	no
55	Brownlee Dam	Snake	285.0	yes	Thermograph	FWPCA/Idaho Power	no	Completely mixed	no
56	Weiser, Idaho	Snake	351.2	yes	None			Well mixed	no
60	Oregon - Idaho Border	Snake	416.0	yes	None			Questionable mixed condition	yes
61	King Hill, Idaho	Snake	545.3	yes	None			Well mixed	no
62	Milner Dam	Snake	640.0	yes	Thermograph	FWPCA	no	No flow during part of year	yes
64	American Falls Dam	Snake	714.0	yes	None			Completely mixed	no

*Instrument site unknown

CONCLUSIONS AND RECOMMENDATIONS

The RTRN reconnaissance surveys were considered successful, providing most of the physical information required for implementation of the RTRN program. Excellent cooperation and suggestions were obtained from the people contacted during the surveys. This cooperation is greatly appreciated.

The primary conclusions and recommendations resulting from the reconnaissance surveys are as follows:

(1) Accurate thermographs are presently operating satisfactorily at thirteen locations on the Columbia River. These units should be incorporated into the network for as long as the operating agencies can maintain them.

(2) Installation of eleven additional thermographs by January 1970, will be limited to "minimum list" locations on the Columbia River and one location on the Willamette River. These eleven thermographs plus thirteen existing units will provide the RTRN with an initial temperature monitoring capability which will meet the requirements of the Columbia River Thermal Effects Study (See Table 2).

(3) Because of possible incomplete mixing conditions during portions of the year, the thermograph recommended on the Columbia River at the Oregon-Washington boundary may not give representative measurements at all times in this reach.

(4) Vertical temperature stratification conditions were found existing at the mouths of the Okanogan, Spokane, and Yakima Rivers due to backwater effects from the Columbia River.

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TABLE 2
REGIONAL TEMPERATURE REPORTING NETWORK SITES
AS OF JANUARY 1970

SITE NUMBER	STATION DESCRIPTION	RIVER	R.M.	THERMOGRAPHS EXISTING	THERMOGRAPHS NEW	REMARKS
1	Harrington Point	Columbia	23.5		x	Temp x-sect. req'd.
2	Clatskanie	Columbia	53.8	x		
3	Longview	Columbia	66.0	x		
5	Prescott	Columbia	75.0	x		
6	Swan Island/St.John's Bridge	Willamette	6.0		x	Temp x-sect. req'd
7	Vancouver	Columbia	106.5	x		
8	Warrendale	Columbia	140.8	x		
10	The Dalles Port Commission Dock	Columbia	189.2		x	
13	Bridge below John Day Dam	Columbia	208.0	x		
16	Umatilla Bridge d/s of McNary Dam	Columbia	290.5	x		
17	Washington - Oregon Border	Columbia	312.3		x	Additional Temp. x-sect req'd.
20	Pasco*	Columbia	329.0	x		
20	Richland*	Columbia	338.0			
23	D/S of Priest Rapids Dam	Columbia	395.6	x		
24	Wanapum Dam	Columbia	415.0		x	Initially for checking purposes.
25	Rock Island Dam	Columbia	453.4		x	
27	Rocky Reach Dam	Columbia	474.5		x	
30	Wells Dam	Columbia	516.6		x	
32	Chief Joseph Dam	Columbia	545.1		x	
33	Bridge d/s of Grand Coulee Dam	Columbia	596.3	x		
34	Little Falls Dam	Spokane	30.0		x	Temp. x-sect. req'd.
35	Kettle Falls*	Columbia	698.6	x		Add. Temp. x-sect. desired.
35	Northport*	Columbia	734.1	x		
41	Ice Harbor Dam	Snake	9.7		x	
		TOTAL THERMOGRAPHS	-	13	11	= 24

* One station will be eliminated from the system in the future

(5) Additional field temperature surveys will be scheduled to adequately define problems related to thermograph measurements at the locations described above.

SPECIFIC THERMOGRAPH SITES BASED UPON 1968 FIELD RECONNAISSANCE SURVEY

Thermograph sites labeled "minimum list" as recommended by participating agencies for the Regional Temperature Reporting Network (RTRN) were investigated during the reconnaissance survey conducted in the summer of 1968. Time limitations or other reasons described in the following paragraphs precluded investigations of some important locations. Existing temperature sensing devices were investigated and rated according to their acceptability for incorporation into the RTRN.

The following paragraphs describe the river conditions, potential vandalism problems, ease of access, and other factors affecting the location and installation of continuous recording thermographs. Each specific thermograph location recommended will be considered temporary until it is determined that its function in the network is critical in a permanent network. The sites discussed in the following paragraphs can be found on Figure 1 and are tabulated in Table 1.

COLUMBIA ESTUARY (Site No. 1)

On October 1, 1968, a temperature reconnaissance survey was conducted at Astoria, Oregon, by FWPCA personnel for the purpose of locating a thermograph site. A detailed temperature cross-section was taken at the Interstate Bridge (RM 13.7). These data were collected during the rising tide. The colder tidal wedge was clearly evident from the temperature profiles and caused considerable "drifting" of the indicated temperature readings at the depth of the mixing zone. Stratification was moderate in the main channel with temperature differences of 2 °C to 3 °C from top to bottom, and quite severe near the Washington shore, with differences of up to 5 °C. It is obvious that thermograph records obtained at this location would be of little value in the RTRN because of the unsteady stratification and lateral variation; therefore, profiles were taken upstream at Tongue Point (RM 18.2). In general stratification was less severe at Tongue Point with only a 1 °C to 2 °C difference between top and bottom. However, just offshore at Tongue Point there is a "hole" in which the temperatures dropped from 14.3 °C to 11.2 °C between depths of 90 to 120 feet. A thermograph, located properly, could yield useful information here, but there is no suitable place to install one. It is felt that Harrington Point (Site No.1) on the Washington shore of the Columbia Estuary (RM 23.5) might provide an adequate thermograph location based upon the decreasing stratification from the Interstate Bridge to Tongue Point during high tide. Before conclusions are reached regarding this location as the terminal point of the RTRN, temperature cross-sections at Harrington Point will be taken.

WILLAMETTE RIVER (Site No.6)

A field reconnaissance survey trip was made on September 30, 1968 in the Portland Harbor for the purpose of locating RTRN thermograph sites. In Portland Harbor temperature cross-sections were taken at:

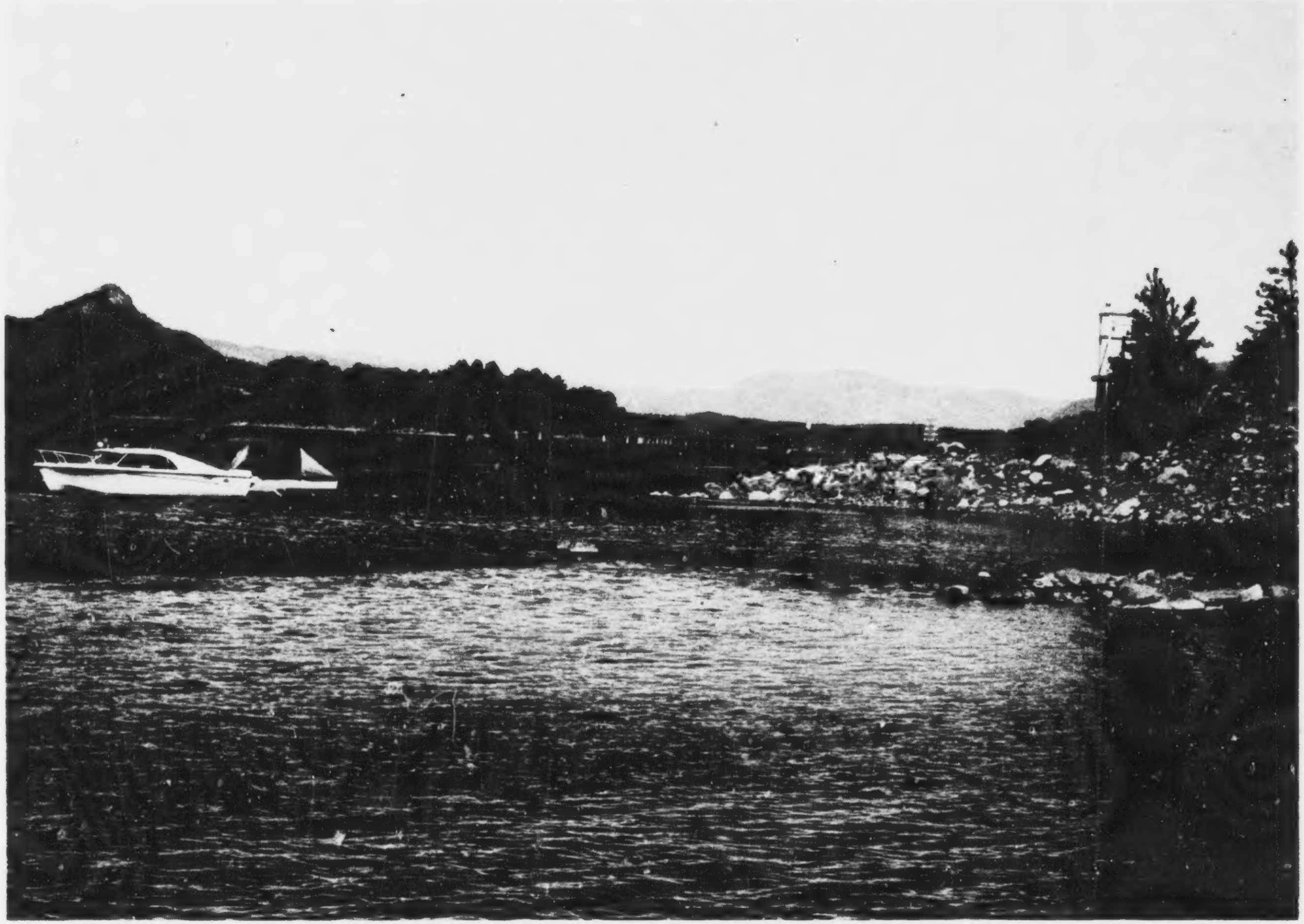
1. Swan Island monitor station
2. St.John's Bridge
3. PGE overhead power lines
4. Willamette main channel just below Multnomah Channel
5. Marker #11 in main channel
6. Willamette main channel just above mouth
7. Columbia River just above Willamette River
8. Columbia River just above tip of Hayden's Island
9. Hayden's Island Slough
10. Multnomah Channel centerline profile at 10 locations down to St. Helens
11. Columbia River just above Multnomah Channel

Portland Harbor was found to be only slightly stratified, with top to bottom differences of about 0.5 °C or less in most locations. Essentially no intrusion of Columbia River water in either the Willamette main channel or Multnomah Channel existed at that time. Average temperatures in Portland Harbor and the Columbia River were 16 °C and 17.5 °C, respectively. It is evident that data obtained on this trip does not represent Portland Harbor conditons at all times; therefore, before a permanent thermograph location is selected, temperature cross-section surveys should be repeated at selected intervals to determine the variability of Columbia River backwater effects upon the Willamette River temperatures. The initial attempt will be to obtain enough temperature and flow data to justify continuation of the Swan Island site. Temperatures during the October 7, 1968 field trip showed the water to be completely mixed at 16.0 °C at Swan Island. An alternative location would be at St. John's Bridge.

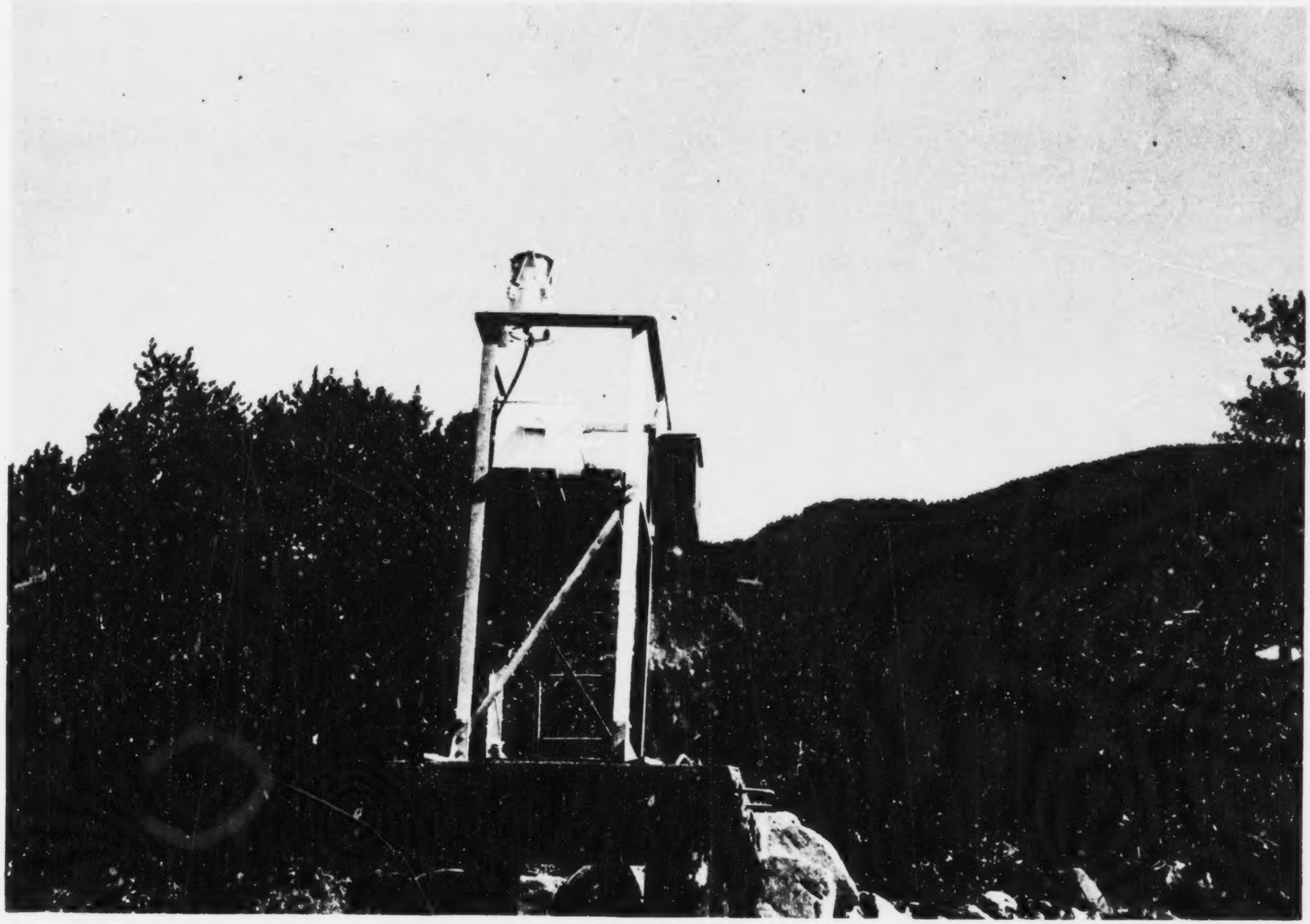
WARRENDALE, OREGON (Site No.8)

Continuous Columbia River water temperature readings are presently being recorded near Warrendale, Oregon, approximately five and one-half miles below Bonneville Dam. The Foxboro thermograph located there was installed by Battelle Northwest under contract to Portland General Electric Company. The Columbia River at this point is completely mixed so that the recorded temperature is representative of the river cross-section. Figure 3 shows the thermograph location on the left bank channel light stand. Figure 4 shows the thermograph (dark box) attached to the light stand. There has been no vandalism at this station in the past.

This location and instrument should be incorporated into the RTRN.



COLUMBIA RIVER AT WARRENDALE OREGON
Looking upstream Note: Thermograph box on right side of photograph
FIGURE 3



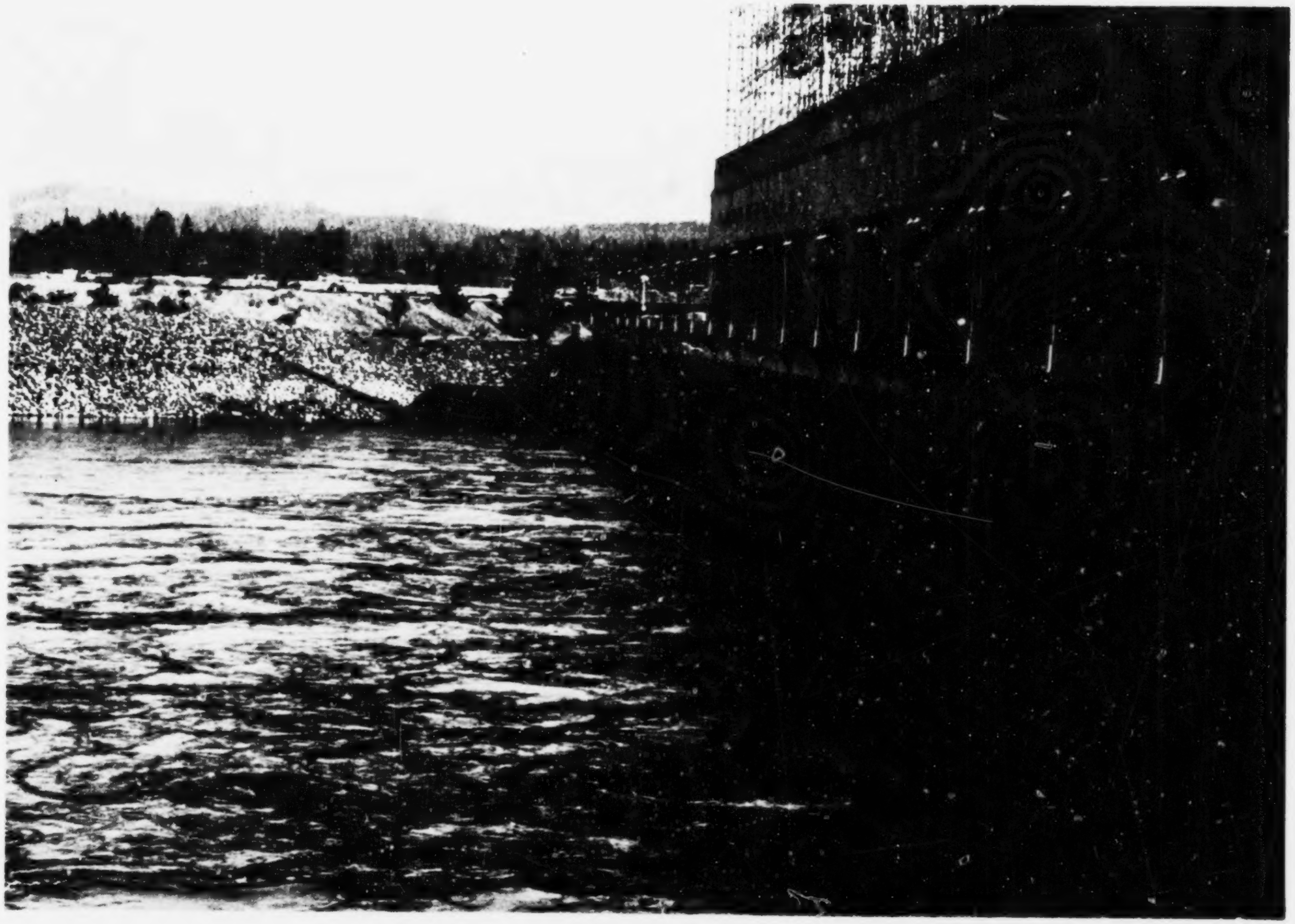
THERMOGRAPH LOCATION AT WARRENDALE OREGON
Looking south at light stand holding thermograph (left bank of river)
FIGURE 4

BONNEVILLE DAM (Site No. 9)

Bonneville Dam was considered as a possible thermograph location but was later eliminated in favor of the Warrendale site. The tailrace discharge at Bonneville Dam is completely mixed and would therefore give a representative temperature of flow releases. FIGURE 5 shows the tailrace condition below Bonneville powerhouse. A continuous recording instrument, if needed, should be located at the north end of the tailrace shown in FIGURE 5, because of a historical debris problem in the center and south portions of the tailrace. Vandalism at this project site is considered minor.

In past years, temperatures have been read and reported by project personnel from thermometers attached to the turbine cooling water lines but, with recent reductions in manpower, these temperatures are no longer taken

Since the Warrendale (Site No.8) thermograph is operating satisfactorily, the Warrendale records can be used to represent the temperature condition below Bonneville Dam. The Bonneville Dam location would be an alternate site.



BONNEVILLE DAM
Looking north at right tailrace embankment (Q=80,000 cfs)
FIGURE 5

THE DALLES PORT COMMISSION DOCK (Site No.10)

The Dalles Port Commission dock, approximately three miles downstream of the Dalles Dam, appears to be a good location for a continuous recording thermograph. The exact thermograph location would be at the northeast corner of the old dock (upstream corner). Site advantages include:

(1) This part of dock is not used; therefore, the instrument will be separated from working personnel and equipment.

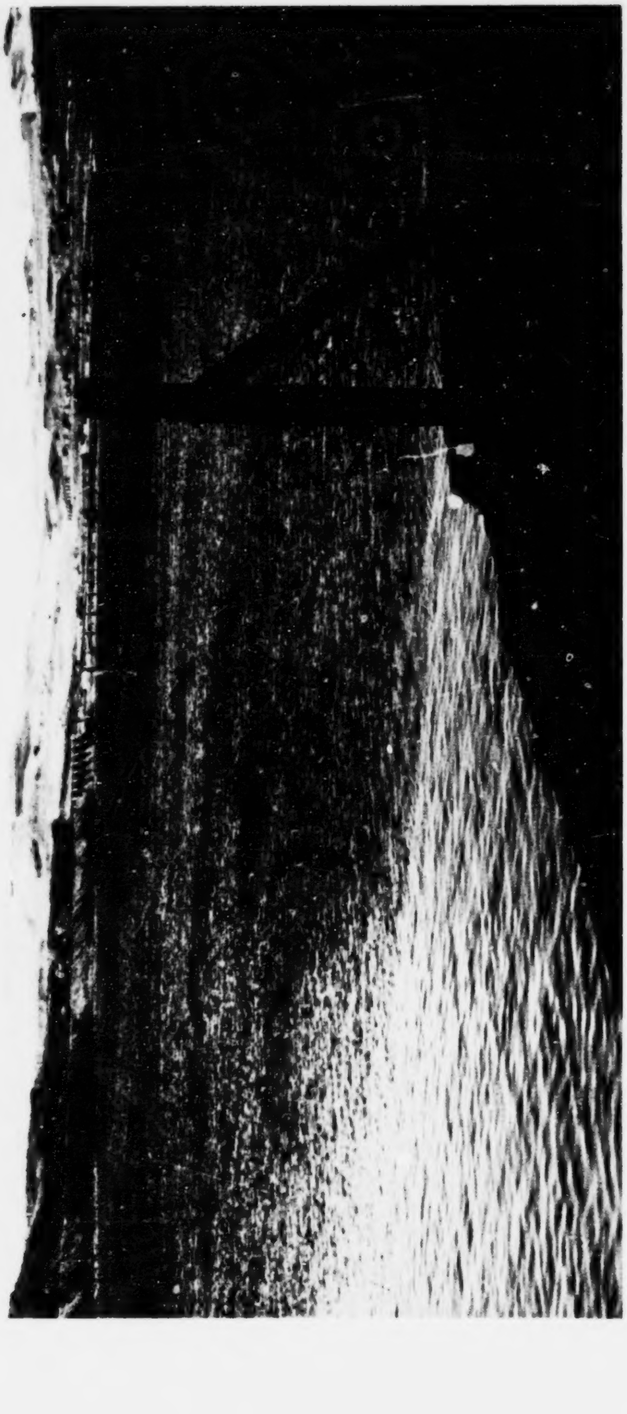
(2) Dock extends out into the river, thereby enabling the thermistor to be in moving water at all times.

(3) Vandalism will be held to a minimum because the area is locked after working hours.

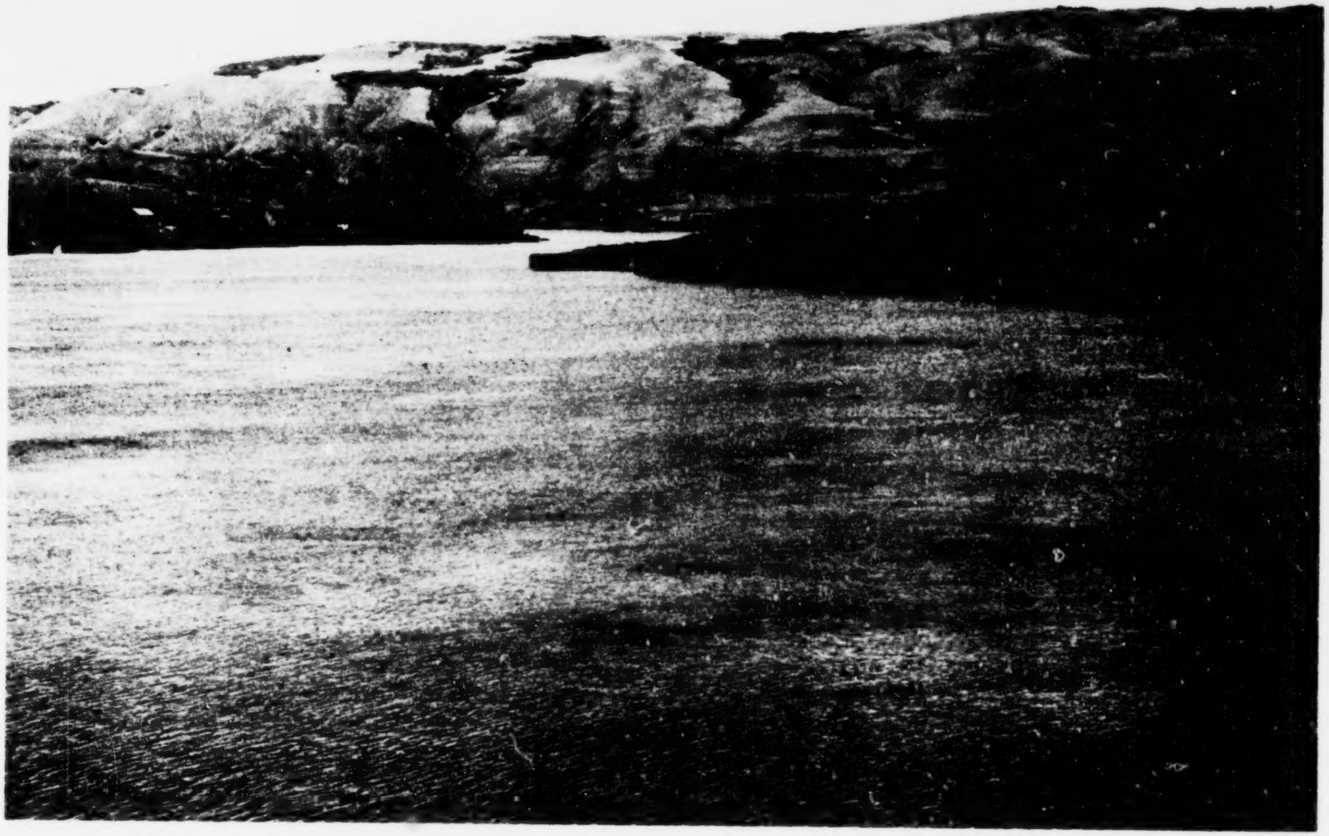
(4) Access to equipment is good during the working day.

Temperature cross-sections of the river were taken at this location on September 6, 1968, with a "Whitney Underwater Thermometer". Temperature varied from 19.83 °C to 19.85 °C throughout the cross-section showing that this portion of the river was completely mixed at that time.

Figure 6 shows a view of the Dalles Dam upstream of the northeast corner of the dock and the picture in Figure 7 was taken looking downstream from the same location.



COLUMBIA RIVER AT THE DALLES PORT COMMISSION DOCK
Looking upstream at the Dalles Dam from the N.E. corner of the old dock (Q=119,000 cfs)
FIGURE 6



COLUMBIA RIVER AT THE DALLES PORT COMMISSION DOCK
Looking downstream and across the river from N.E. corner of the old dock
FIGURE 7

THE DALLES DAM (Site No.11)

The Dalles Dam was considered as a possible location for a thermograph but was later eliminated in favor of The Dalles Port Commission Dock. The dam tailrace and turbine cooling water lines were considered as potential locations for the temperature sensors. The possibility of turbine shut downs, however, could give erroneous readings if the thermograph were connected to the affected cooling water lines. Because of this and adverse location of the tailrace relative to the spillways, it was believed that The Dalles Port Commission Dock location would yield better temperature information.

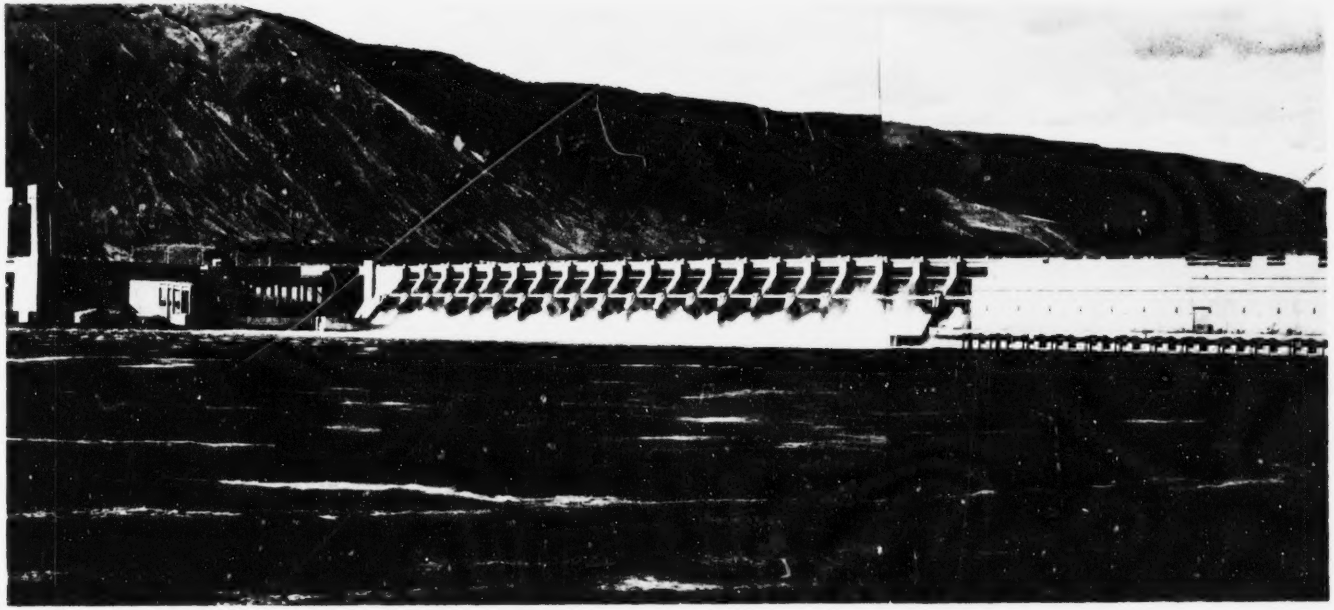
Temperatures are now being taken from a bulb thermometer in the turbine scroll case but due to the desirability of an accurate continuous recording thermograph in the network, thermometer temperature measurements are not acceptable.

JOHN DAY DAM (Site No. 13)

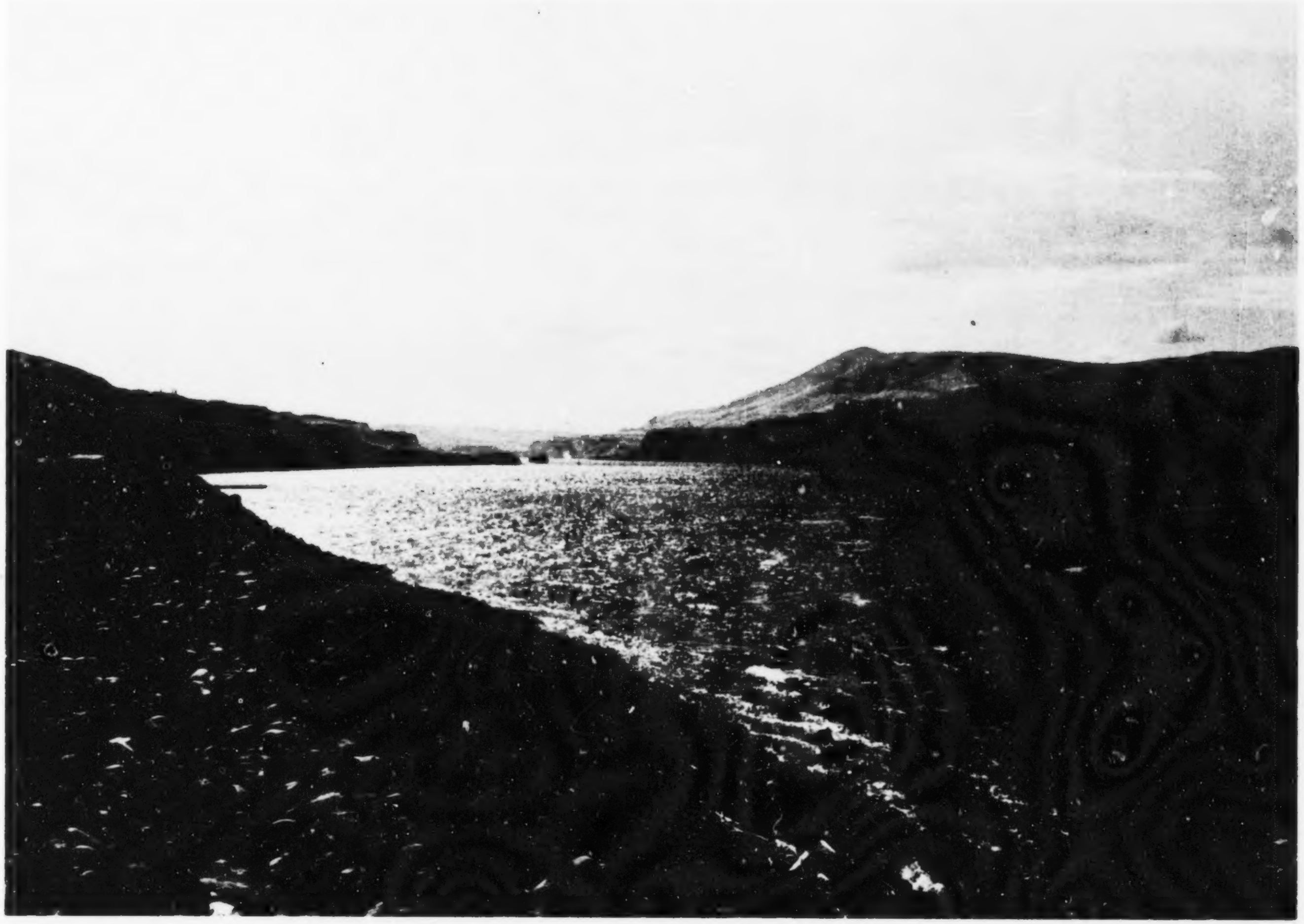
John Day Dam was still under construction during the August 20, 1968, reconnaissance field trip (see Figure 8). The initial plan was to place a thermograph in the dam tailrace, but since the majority of the turbines are not scheduled to be in place until November, 1971, another location had to be investigated for inclusion into the initial RTRN phase.

Battelle Northwest under contract to AEC has installed a Foxboro thermograph at the Interstate Toll Bridge (RM 208) approximately 7½ miles below John Day Dam. The river at the bridge is completely mixed and should remain so after the flow is routed through the turbines. It is concluded that this thermograph should be incorporated into the network and its records be considered nearly representative of the dam discharge temperature. Figure 9 shows the Columbia River downstream of the bend shown in the photograph.

Vandalism should be minor at the bridge location since the toll bridge is tended at all times.



JOHN DAY DAM
Looking upstream at dam tailrace (Q-100,000 cfs)
FIGURE 8



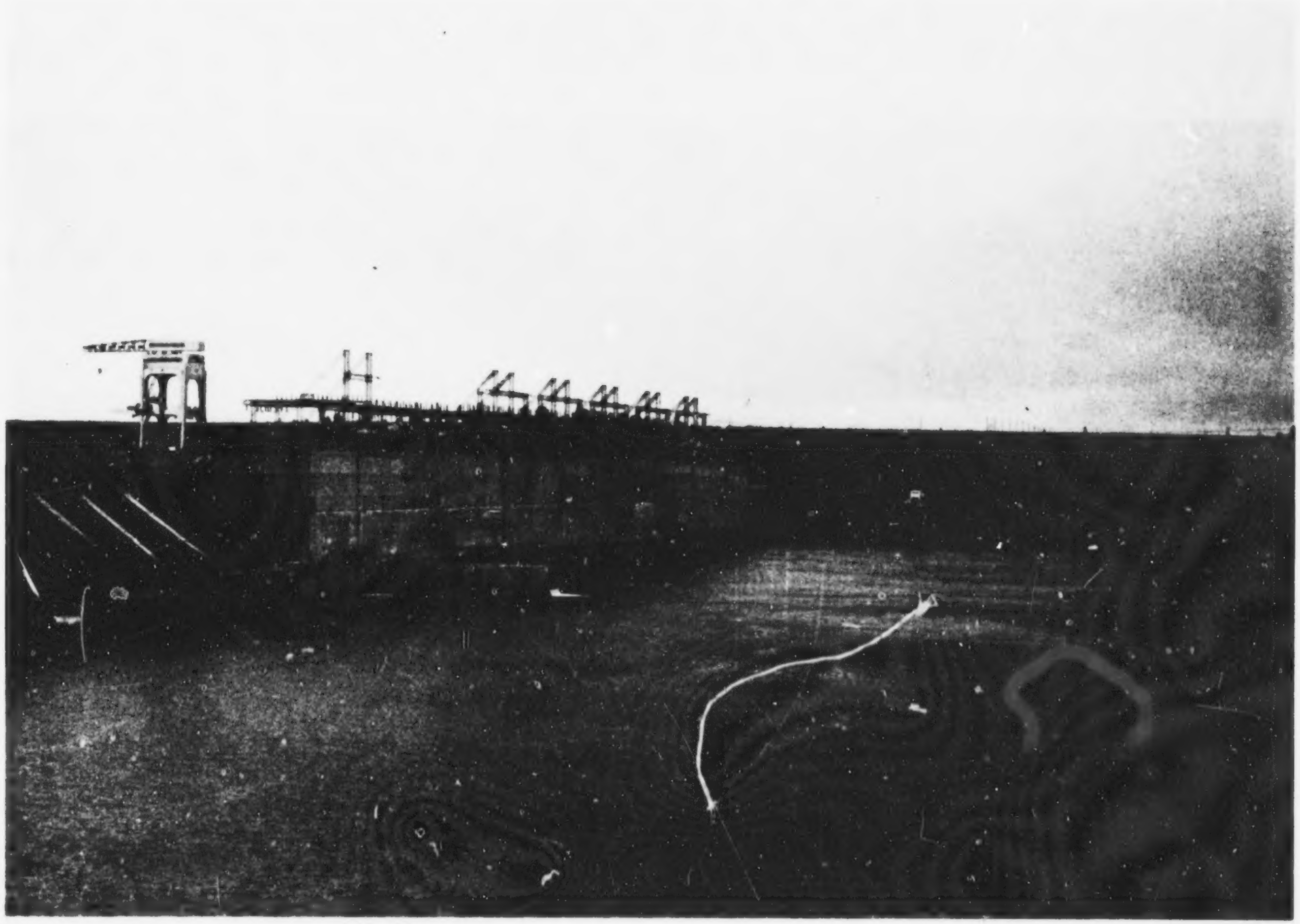
COLUMBIA RIVER BELOW JOHN DAY DAM
Looking downstream from dam (Interstate bridge just downstream of bend of river)
FIGURE 9

BELOW McNARY DAM (Site No.16)

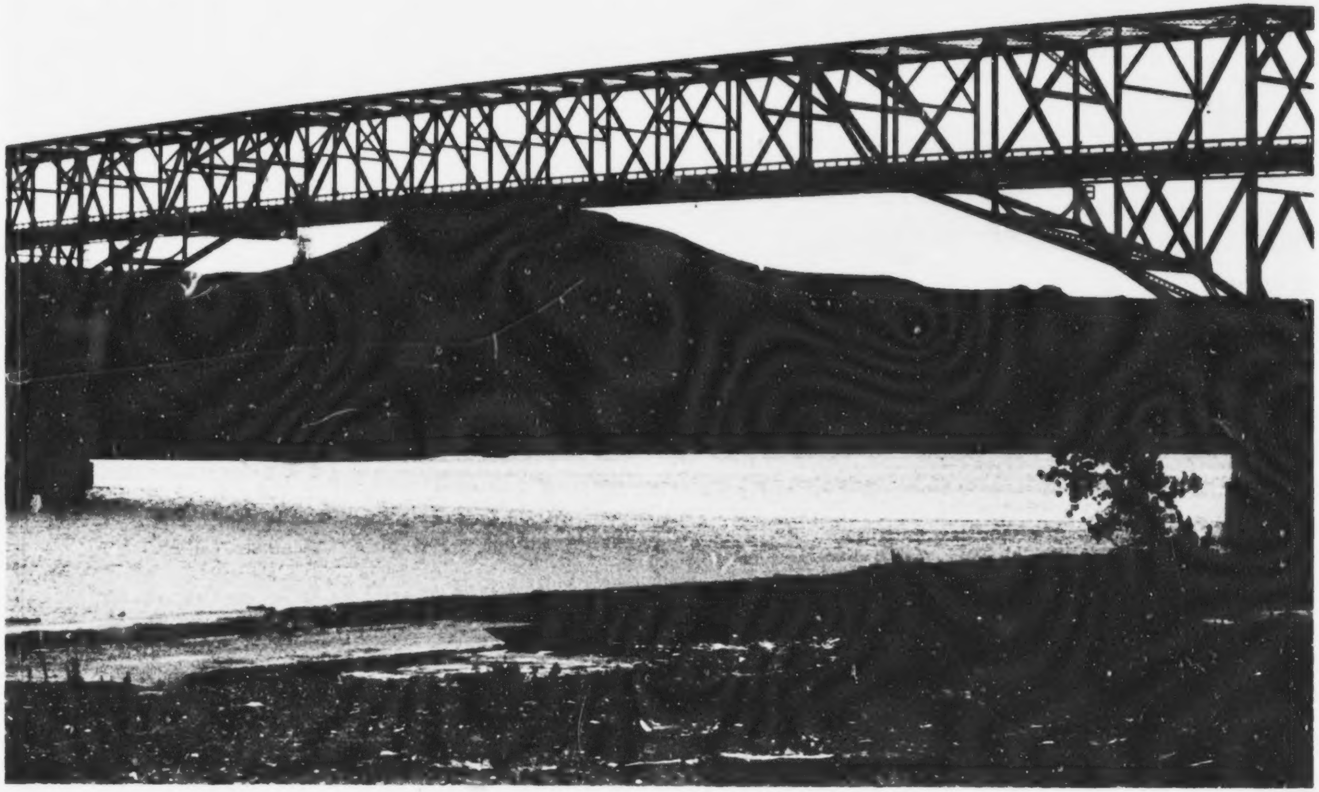
Sites at both McNary Dam (Figure 10) and the Umatilla toll bridge (Figure 11) downstream of the dam were investigated. A Foxboro thermograph was installed at the bridge by Battelle Northwest under contract with AEC and is currently providing river temperature data . The Umatilla Toll Bridge is tended at all times which would provide some protection against vandalism. The dam location is protected from vandalism and the tailrace is completely mixed although the thermistor could be damaged by debris in the tailrace during spilling operations.

The McNary project has the thermometers connected to the turbine cooling water lines which are not adequate for the network system, as discussed earlier, due to the need for a continuous, accurate record.

The existing thermograph at the Umatilla Bridge location (RM 209.5) is adequate for the RTRN system and should be included into it. The decision for the bridge location is also based on (1)the debris problem at the dam and (2) the possibility of a lateral stratification in McNary forebay which could produce an unequal temperature distribution in the tailrace.



McNARY DAM
Looking south at trailrace area toward Oregon shore (Q=140,000 cfs)
FIGURE 10



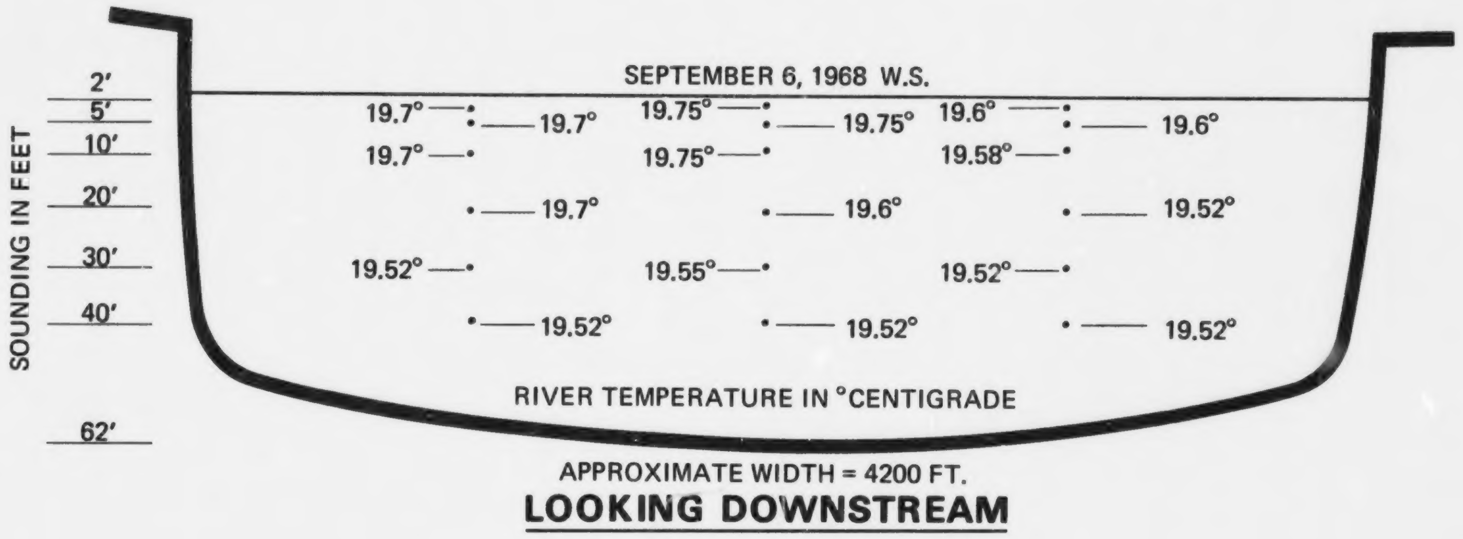
UMATILLA BRIDGE BELOW McNARY DAM
Looking upstream at bridge (Q=140,000 cfs)
FIGURE 11

WASHINGTON-OREGON BORDER (Site No. 17)

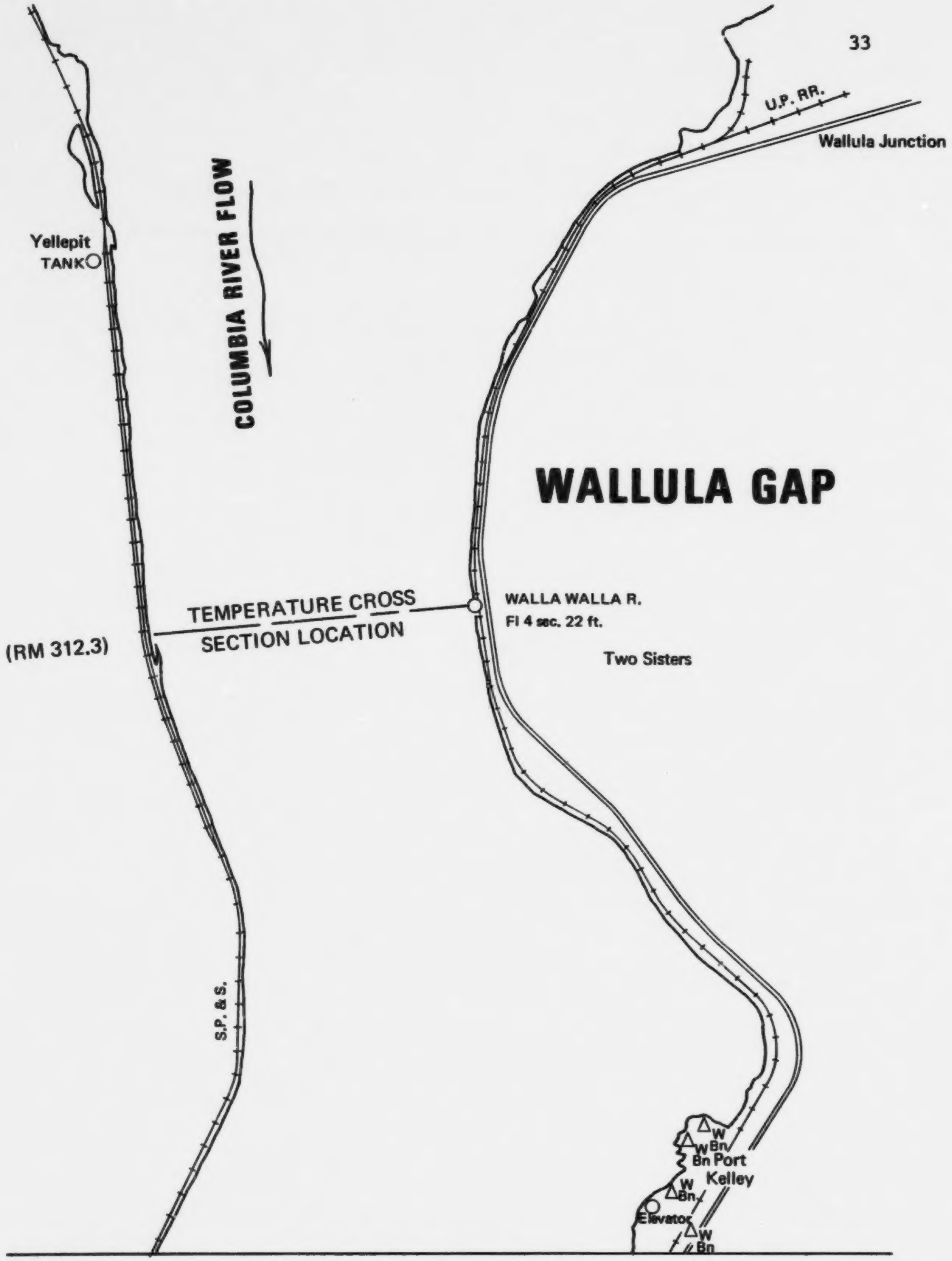
Locating a continuous recording thermograph downstream of the Columbia and Snake River confluence is of particular importance in determining what temperature influence the Snake River has on the Columbia River below the confluence and for monitoring river temperatures close to the Oregon-Washington border for "water quality standards" surveillance.

On September 5 and 6, 1968, temperature cross-sections were taken at various locations between McNary Dam and the Snake River in order to locate a completely mixed section. Cross-sections were taken approximately 2,6,13,27, and 32 miles below the confluence. During that time period the Columbia River was stratified both vertically and laterally with the warmer water on the left side of the river beginning at the confluence and extending down to Wallula Gap (RM 312.3, 13 miles below confluence) where the river contracts to a width of approximately 4200 feet. At this location the temperature in the cross-section ranged from 19.52 °C to 19.70 °C throughout the width and depth (see Figure 12 & 13). Thermograph instrumentation could be placed in the vicinity of the Walla Walla River flashing light installation or across the river (Washington side). Cross-sections taken downstream from this point showed the river again stratified vertically and laterally but with the warmer water shifted to the Washington side of the river. This temperature pattern continued downstream to McNary Dam.

Location of a continuous recording thermograph at Wallula Gap would yield the most representative temperature results in the reach. Before long range adequacy of this installation can be determined, temperature cross-sections during various times of the year are required.


SEPTEMBER 6, 1968 W.S.
SOUNDING IN FEET
2′
5′
10′
20′
30′
40′
62′
19.7°
19.7°
19.75°
19.75°
19.6°
19.6°
19.7°
19.75°
19.58°
19.7°
19.6°
19.52°
19.52°
19.55°
19.52°
19.52°
19.52°
19.52°
RIVER TEMPERATURE IN °CENTIGRADE
APPROXIMATE WIDTH = 4200 FT.
LOOKING DOWNSTREAM

COLUMBIA RIVER BETWEEN MCNARY DAM AND THE SNAKE RIVER (R.M. 312.3)
Temperature cross-sections taken on September 6 1968
FIGURE 12


Yellepit
TANK
COLUMBIA RIVER FLOW
U.P. RR.
Wallula Junction
WALLULA GAP
TEMPERATURE CROSS SECTION LOCATION
(RM 312.3)
WALLA WALLA R.
Fl 4 sec. 22 ft.
Two Sisters
S.P. & S.
W Bn
W Bn
Port Kelley
W Bn
Elevator
W Bn

COLUMBIA RIVER BETWEEN MCNARY DAM AND THE SNAKE RIVER
Temperature Cross-Section Location
FIGURE 13

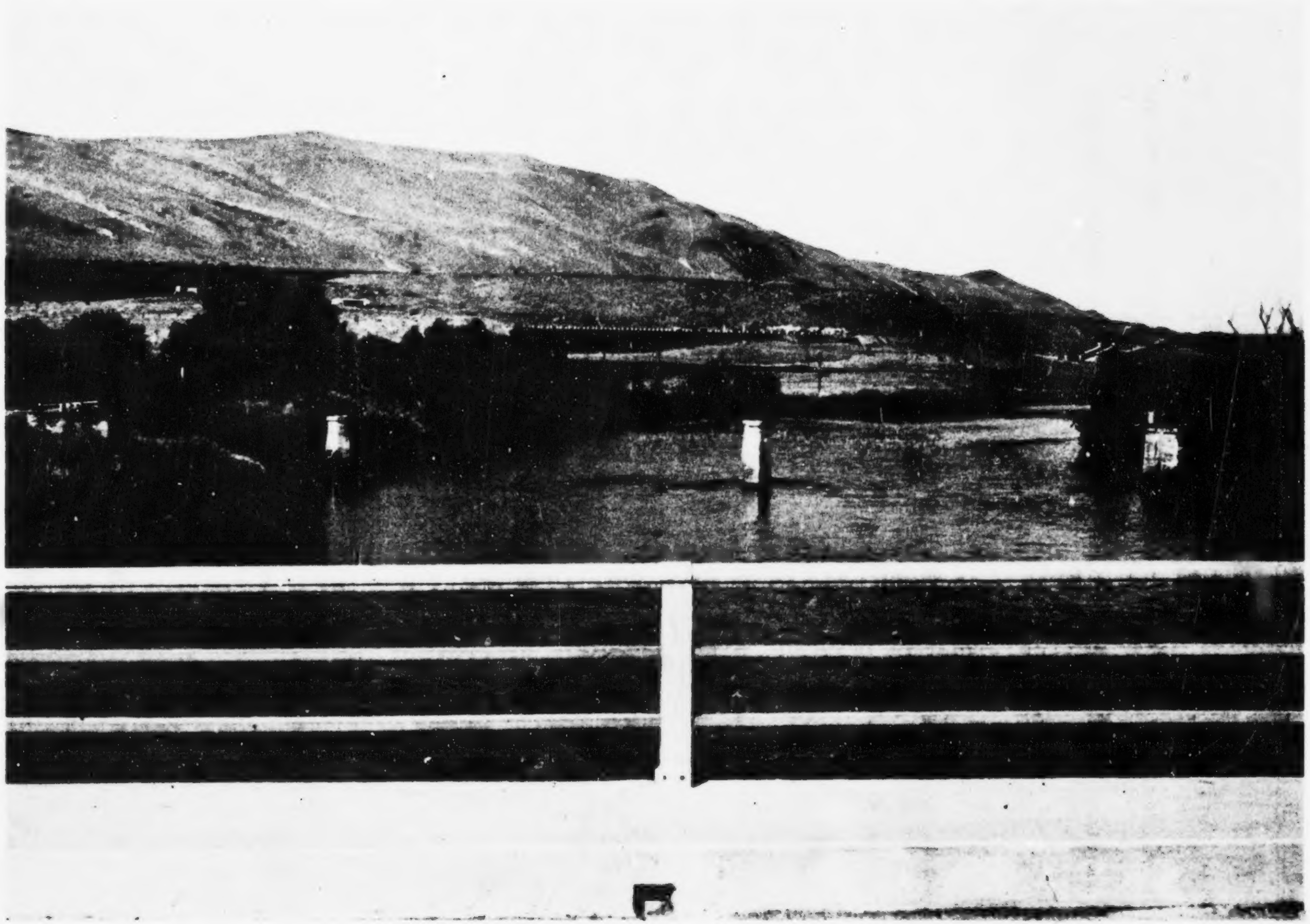
YAKIMA RIVER (Site No.19)

The Yakima River, tributary to the Columbia River, is a major tributary and as such contributes to the thermal loading in the Columbia River.

Temperature cross-sections taken on August 21, 1968, at the bridge crossing the Yakima River at Kiona, Washington (Figure 14), just downstream of the USGS Kiona gaging station, indicated a uniform 17.3 °C temperature. A temperature sensor is scheduled to be installed at the gaging station by mid-summer, 1969, as part of the "Hydromat" telemetering system.

Survey temperature measurements indicated that a thermograph location closer to the Columbia River than the Kiona gaging station would be preferable because of stratification due to backwater effects.

It has been suggested by scientists from Battelle Northwest that a location at the highway bridge at West Richland would yield a well mixed temperature condition, unaffected by the Columbia River backwater. Conclusions regarding a station on this river cannot be reached until the West Richland site can be investigated.



KIONA BRIDGE OVER THE YAKIMA RIVER
Looking upstream at the Kiona gauging station on the right side of the photograph
FIGURE 14

COLUMBIA RIVER IN RICHLAND VICINITY (Site No. 20)

Battelle Northwest under contract with AEC has installed Foxboro thermographs at the Richland, Washington water intake and at Pasco, Washington. Battelle Northwest is presently comparing temperature results of the two stations in an attempt to determine the most representative location.

It appears that either instrument location selected would be adequate for the network and should be incorporated into it.

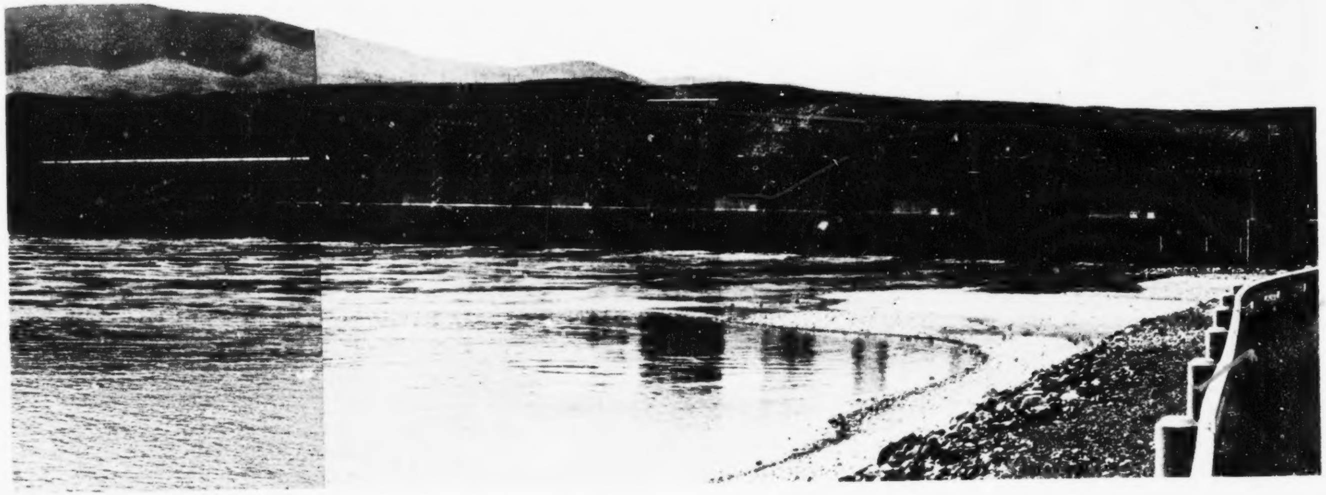
PRIEST RAPIDS DAM (Site No. 23)

A Leeds Northrup continuous recorder was installed during the construction of Priest Rapids Dam. The temperature sensors were installed in each turbine scroll case and record water temperatures of the turbines successively at 30 second intervals between turbines. Comparisons of temperatures taken on August 21, 1968, with the "Whitney Underwater Thermometer" in the forebay and tailwater and temperatures recorded at the same time on the projects thermograph showed favorable agreement, however, further investigation at this location should be made before accepting the results as being representative of dam discharge conditions.

Battelle Northwest under contract with AEC has installed a calibrated Leeds Northrup strip-chart type thermograph at the U.S.G.S. gaging station (RM 395.6) approximately 1½ miles downstream of Priest Rapids Dam. The temperature information from this site is presently being reported as representative of this river reach. The instrumentation and location are adequate for the RTRN system; therefore, this thermograph should be included in the network.

WANAPUM DAM (Site No. 24)

Wanapum Dam has a Leeds Northrup thermograph which records the temperature of water flowing through each turbine, using a temperature sensor in each scroll case. Field verification surveys will be required to determine whether this instrument should be included in the network. The tailrace is completely mixed so that thermograph measurements will be representative of the discharge conditions. A recorder can be placed on the tailrace deck (see FIGURE 15). Comparison of temperature data from the tailrace and scroll cases will determine whether the scroll case thermographs are adequate for the RTRN system. If so, the tailrace thermograph can be removed in favor of the project recorder.



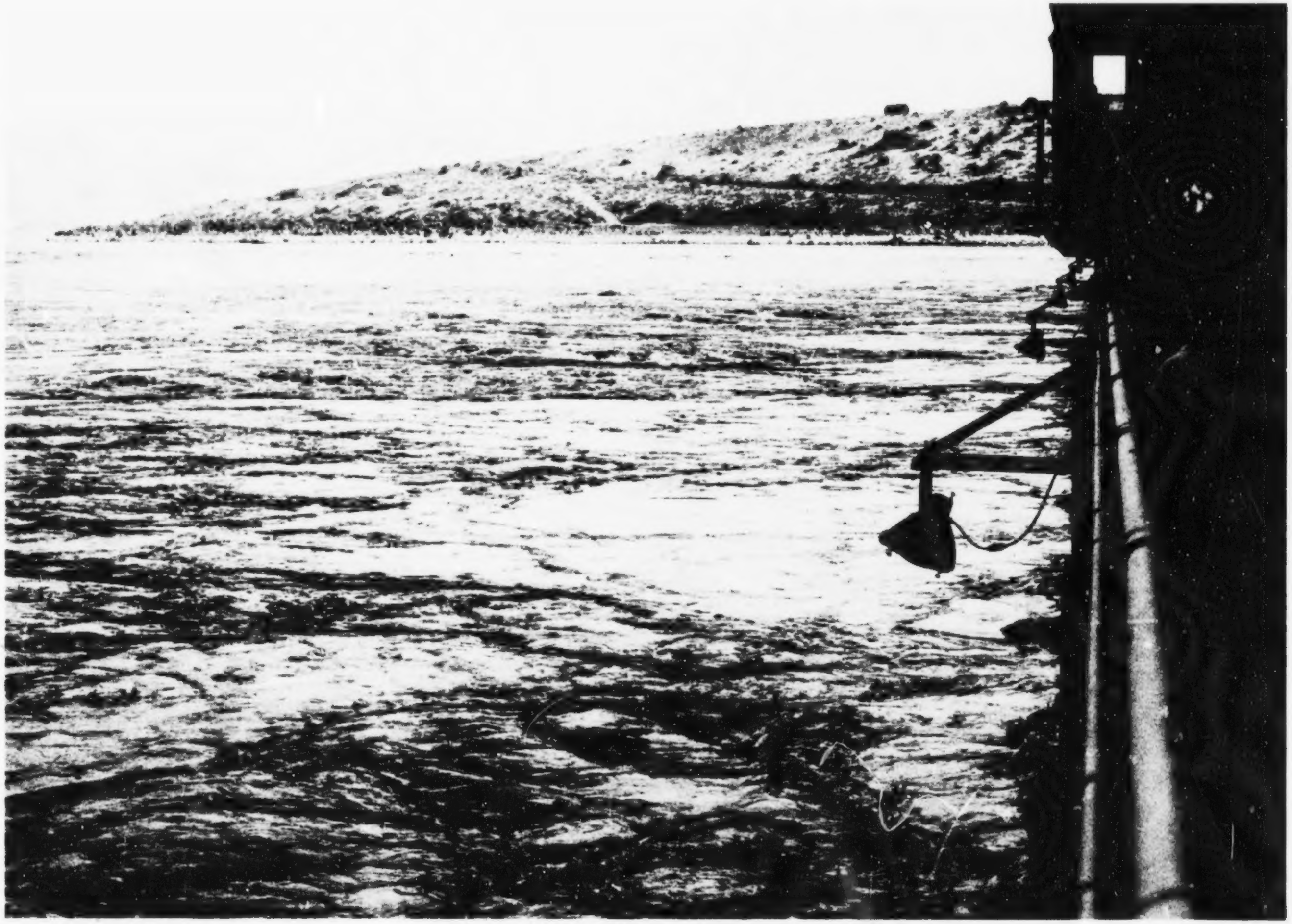
WANAPUM DAM
Looking upstream at powerhouse and tailrace (Q 147,000 cfs)
FIGURE 15

ROCK ISLAND DAM (Site No. 25)

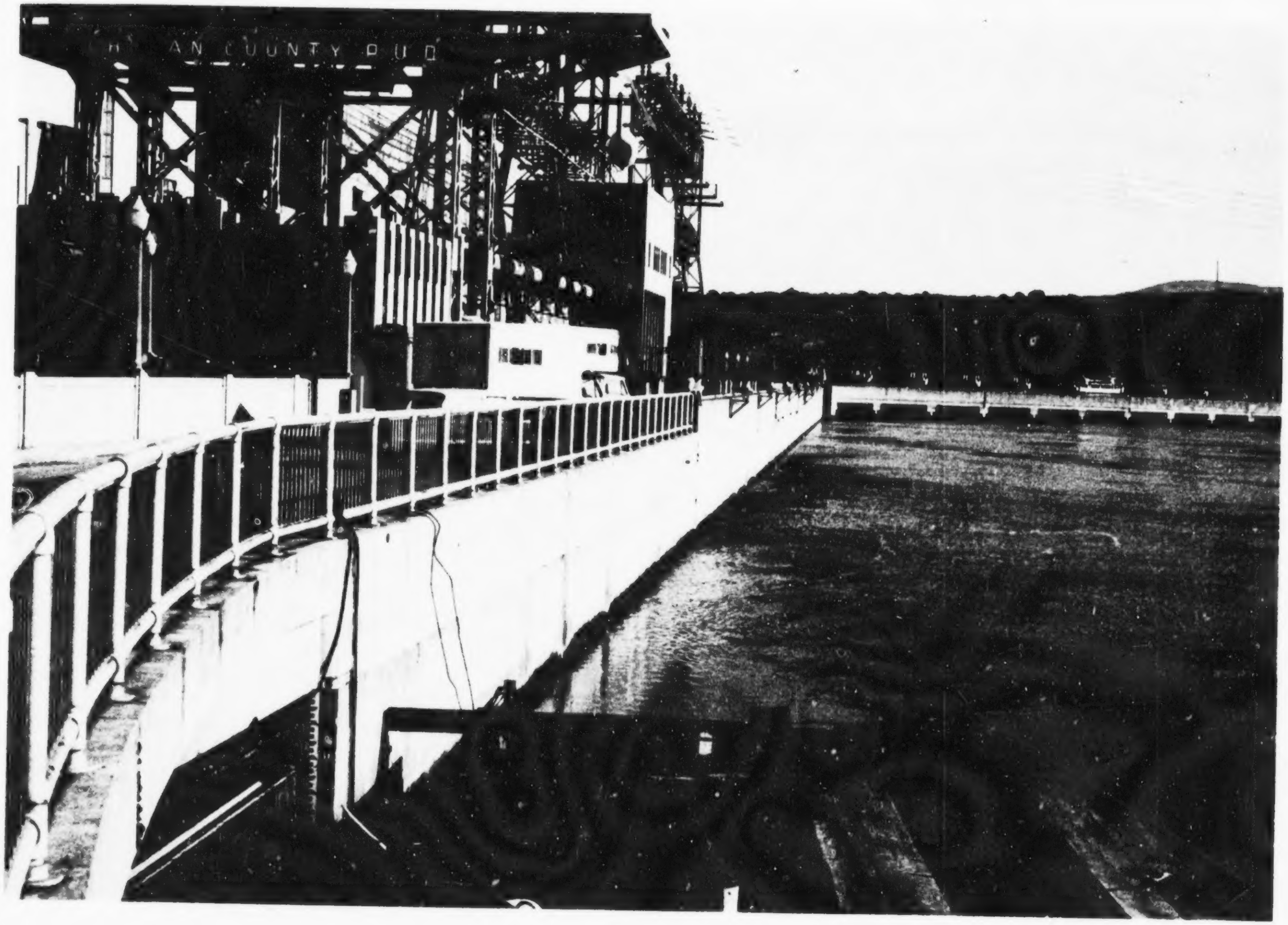
Several thermograph sites were investigated at Rock Island Dam. The tailrace level at the dam is controlled by Wanapum Dam downstream and during the spring floods the Rock Island tailrace deck has been inundated. Due to the possibility of losing the instrument during high flows, the tailrace was eliminated as a potential thermograph location. The tailrace which is highly turbulent and completely mixed is shown in FIGURE 16.

The forebay was also investigated as a possible thermograph site. Temperatures were taken (August 21, 1968) in the forebay and tailwater for comparison. The forebay (FIGURE 17) was completely mixed at a temperature of 16.60 $^{\circ}$C and the tailwater yielded a reading of 16.50 $^{\circ}$C. The Columbia River current approached the dam along the left shore and then flowed transversely across the upstream face of the dam (from left to right) into the turbines and spillways.

Locating a thermistor sensor in this transverse flow in the forebay (approximately at the location of the people in the photograph) is suggested and would yield temperatures representative of the river temperature above and below the dam.



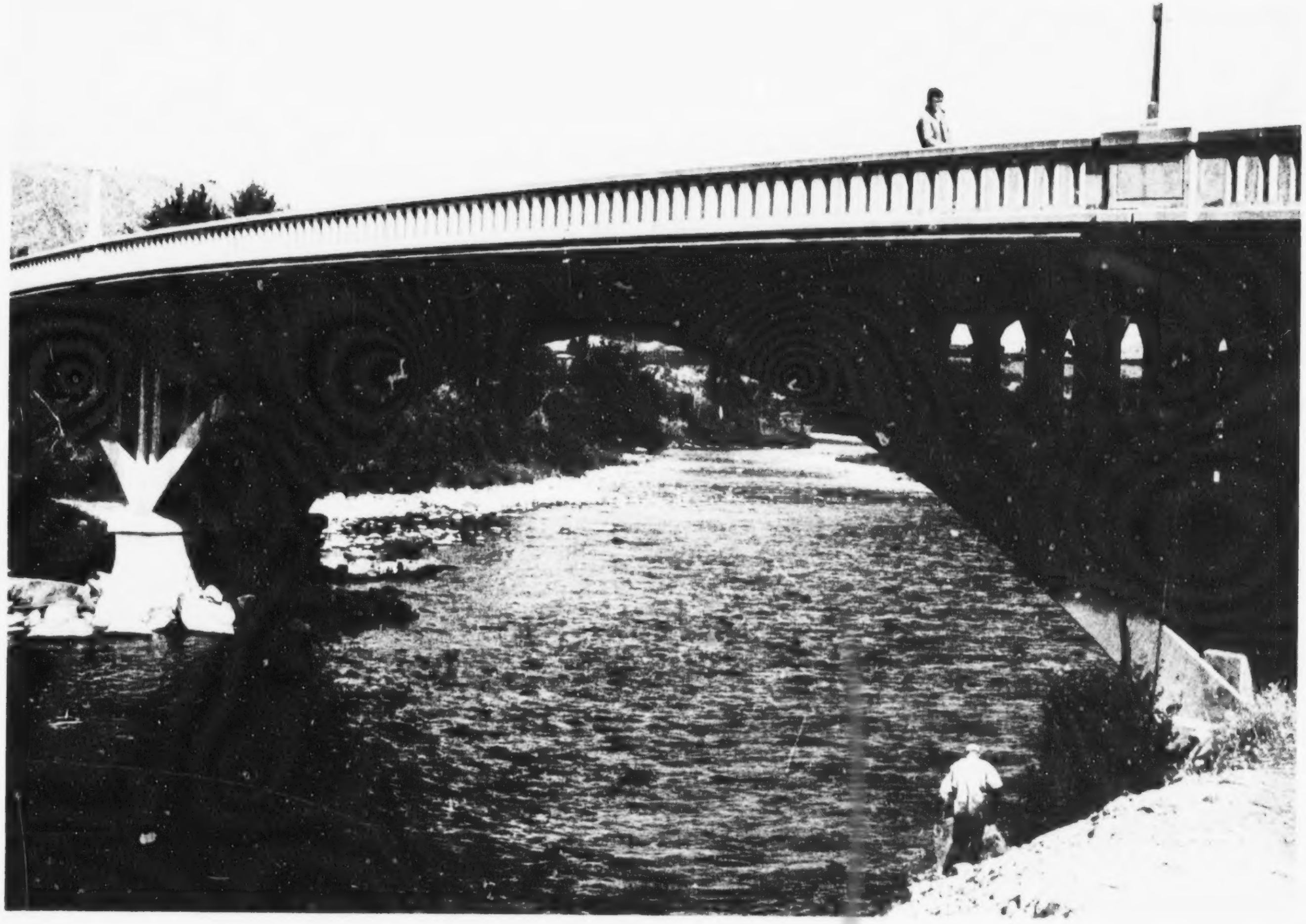
ROCK ISLAND DAM
100,000
Looking west across tailrace of Dam (Q=1000,000 cfs)
FIGURE 16


AN COUNTY PUD

ROCK ISLAND DAM
Looking west across forebay of Dam (current toward opposite shore-Q=100,000 cfs)
FIGURE 17

WENATCHEE RIVER (Site No. 26)

The Wenatchee River was selected as one of the streams requiring temperature monitoring in the initial stage of the program. FIGURE 18 shows the bridge over the Wenatchee River at Monitor, Washington, which is a potential thermograph site for this important Columbia River tributary. This location is far enough upstream to be out of the Columbia River backwater effect and temperature cross-sections which were taken on August 22, 1968, showed the river to be well mixed and fairly cold (13.25 °C). A thermograph located at this site will have to be heavily protected against potential vandalism.



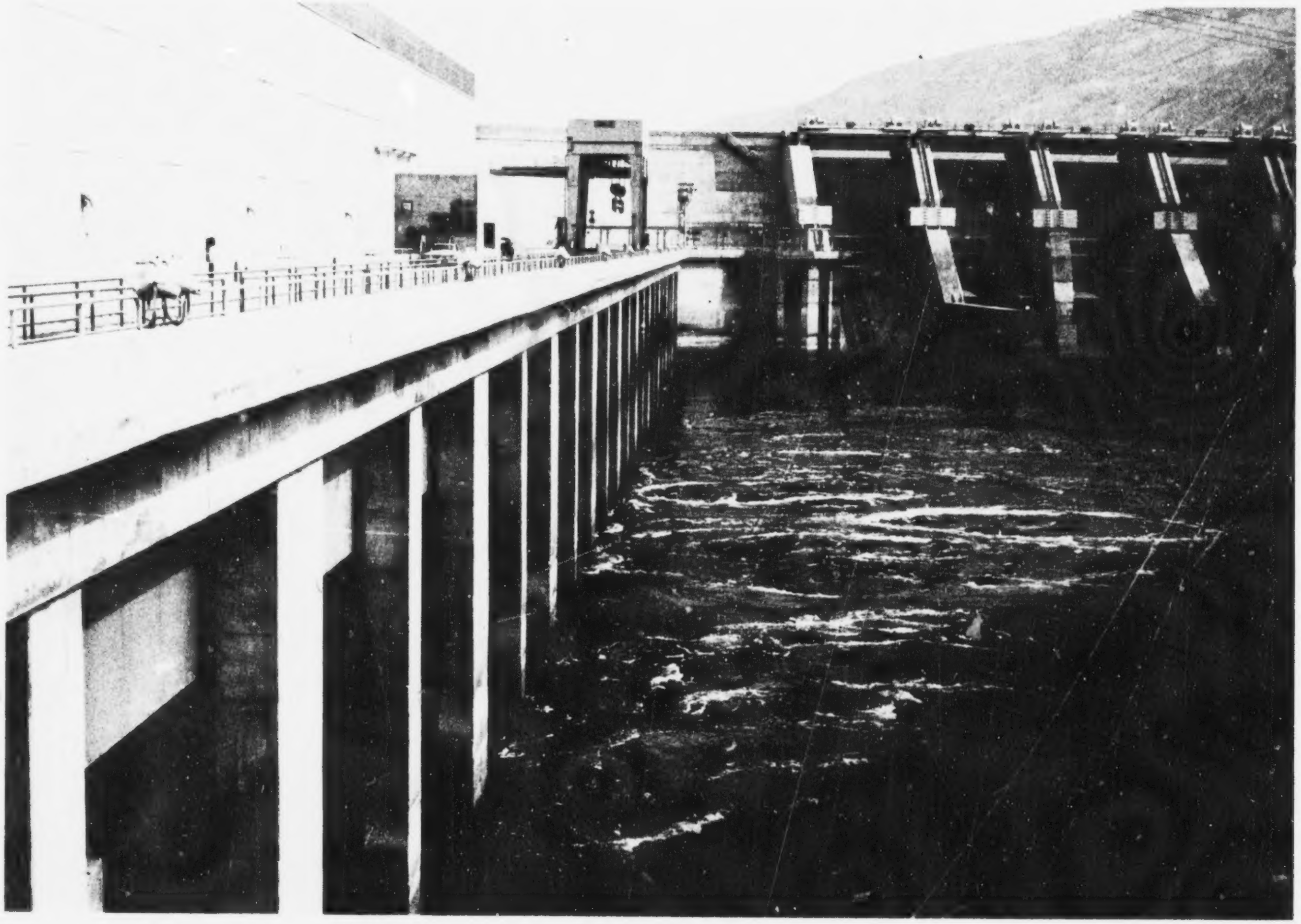
BRIDGE OVER THE WENATCHEE RIVER AT MONITOR, WASHINGTON
FIGURE 18

ROCKY REACH DAM (Site No. 27)

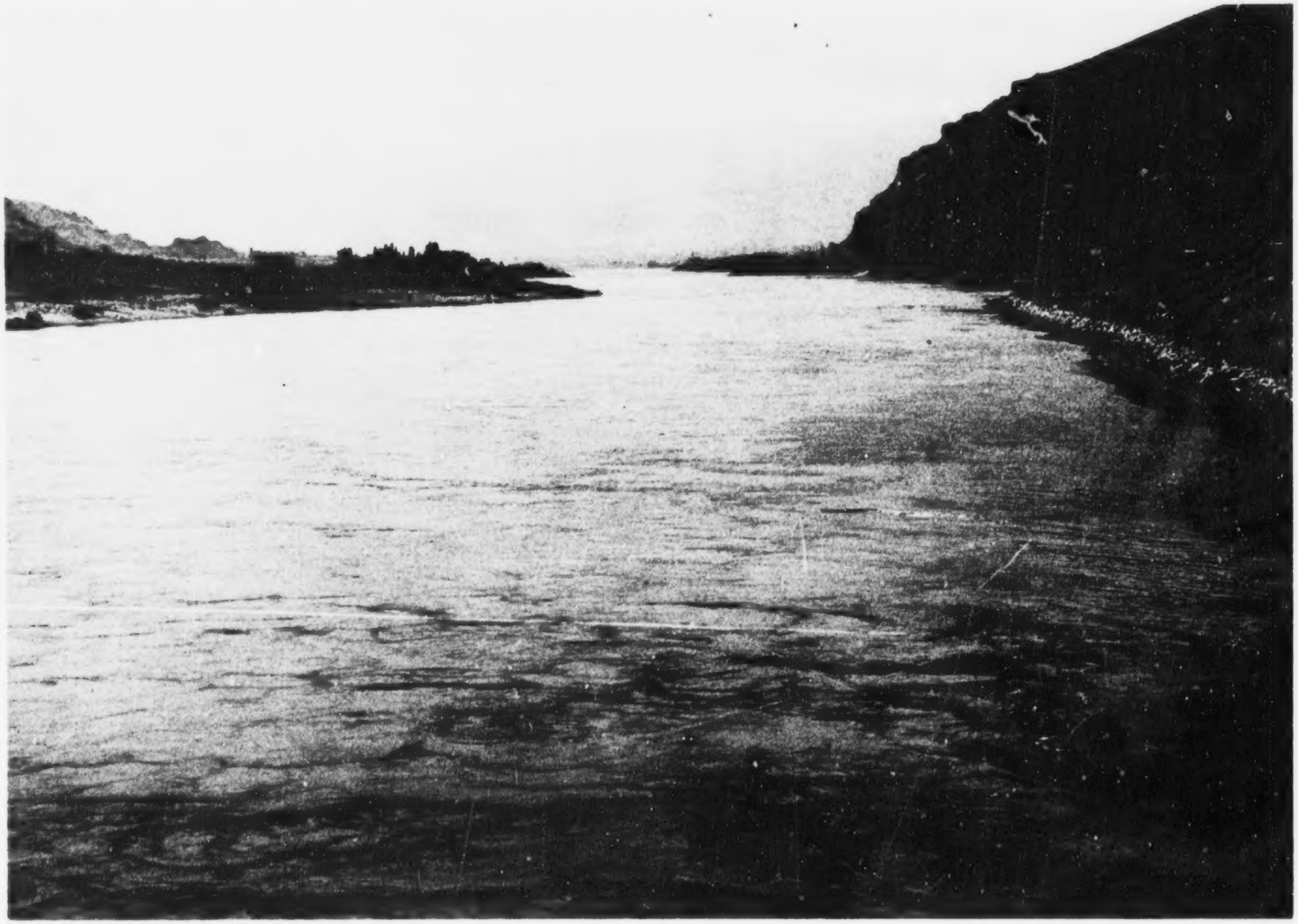
The tailrace of Rocky Reach Dam is considered a good location for monitoring discharge temperature. The tailrace shown on FIGURE 19 is completely mixed and FIGURE 20 shows the turbulent conditions downstream of the dam.

A Leeds Northrup scroll case thermograph was installed during project construction and is currently operating. Battelle Northwest has installed a thermometer in the turbine cooling water lines. Temperatures are read and reported by the project personnel hourly. On August 22 1968, FWPCA personnel monitored forebay and tailrace temperatures with a "Whitney Underwater Thermometer" and compared results with those from the two existing monitoring devices for the same time period. Comparison of results showed that temperatures of the forebay, tailrace and thermometers were in close agreement whereas the scroll case thermograph results were approximately 1.5 °C colder,

A continuous recording thermograph should be placed in the tailrace and these records used instead of the existing information obtained from the other devices. The thermograph will not interfere with project operation on the tailrace deck. The thermometer, even though accurate, cannot be incorporated into the RTRN due to the need for accurate continuous records.



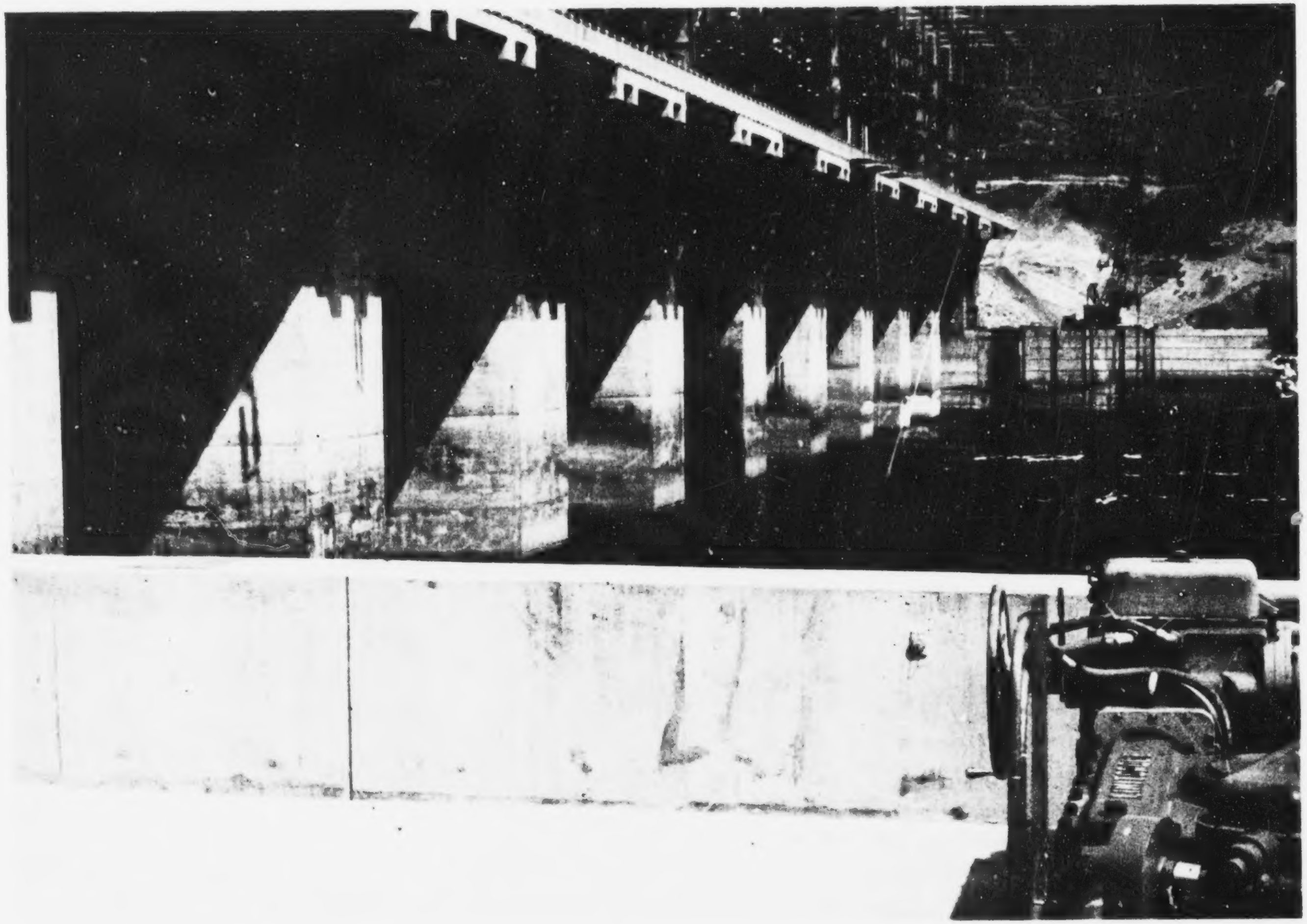
ROCKY REACH DAM
View of Tailrace (Q=96,000 cfs)
FIGURE 19



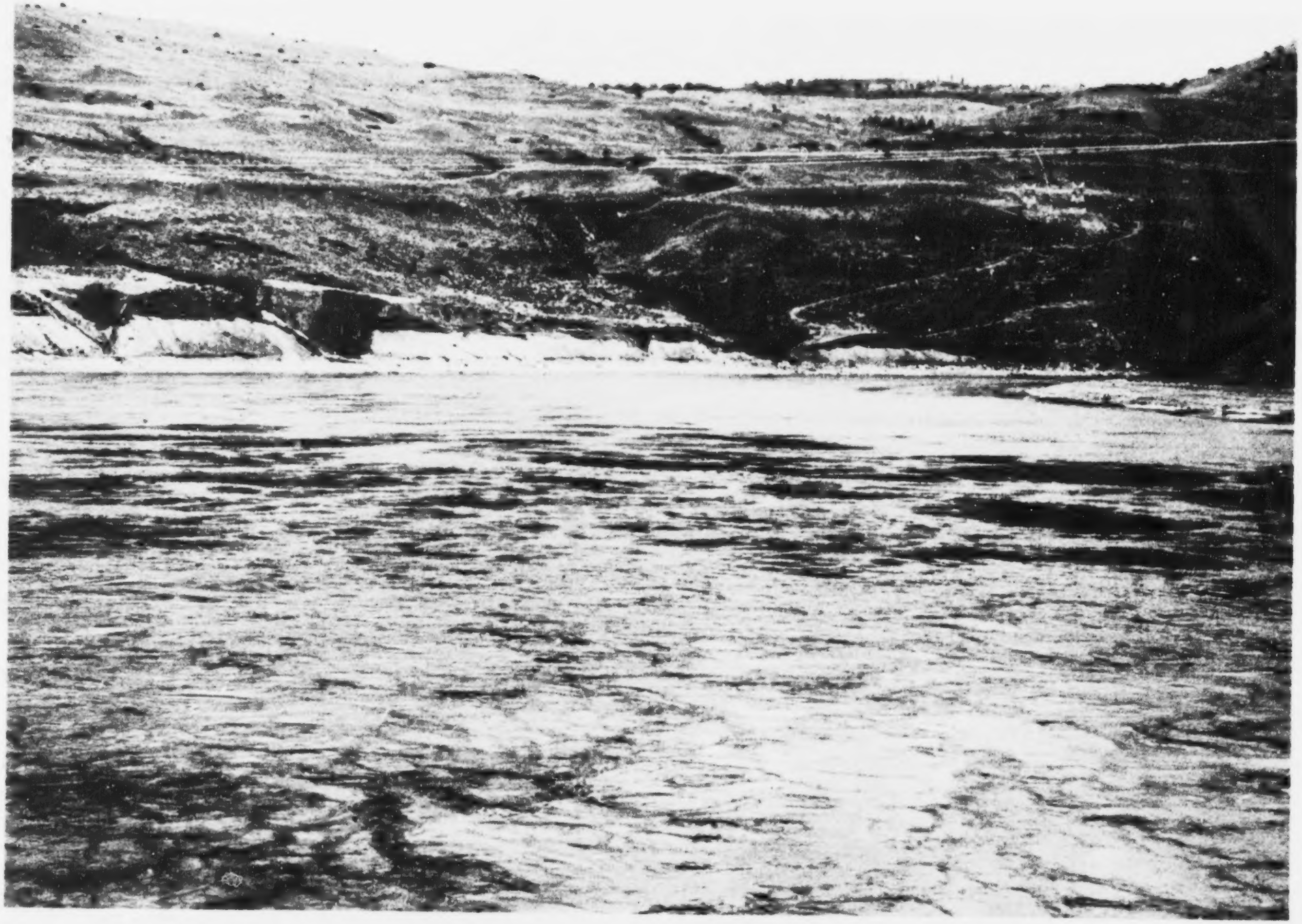
ROCKY REACH DAM
Looking downstream from powerhouse deck (Q=96,000 cfs)
FIGURE 20

WELLS DAM (Site No. 30)

Wells Dam was still under construction when field reconnaissance survey personnel visited the site. The project manager suggested that the lower tailrace deck on the right bank of the river (shown on FIGURE 21) would be the most acceptable location for the thermograph. Temperature spot checks taken in the tailrace indicate that it is completely mixed; therefore, a thermograph placed at this location would yield representative temperatures. It is suggested that thermistor leads be placed through a pipe connected to the side of the tailrace wall because of the turbulent conditions caused by spillway flows (spillway and turbines are alternately spaced along axis of dam). FIGURE 22 shows the river downstream of dam.



WELLS DAM
Looking at tailrace and right bank tailrace wall
FIGURE 21



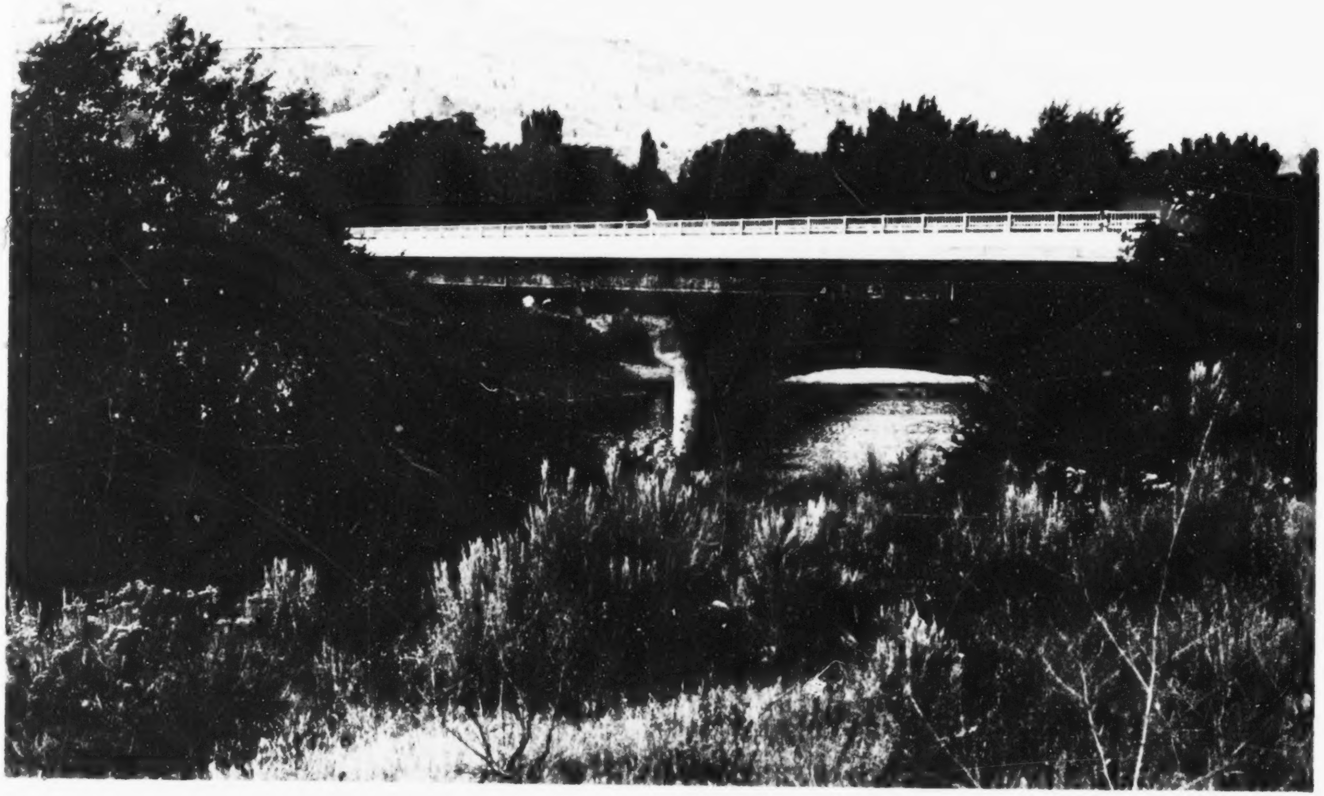
WELLS DAM
Looking downstream from tailrace deck
FIGURE 22

OKANOGAN RIVER (Site No. 31)

Potential sites on the Okanogan River were investigated for a thermograph location on August 22, 1968. Temperature cross-sections were taken at two sites above the mouth of the Okanogan River; one at a bridge at Monse, Washington and the other at a bridge near Malott (FIGURES 23 and 24) approximately 13 miles above the mouth. The Monse location was definitely under the influence of Wells Dam backwater as shown by a vertical temperature stratification of approximately 2.3 °C (18.25 to 20.58 °C.) The Malott site investigated had a slight backwater effect and a temperature stratification of approximately 1.6 °C (19.70 °C to 21.30 °C).

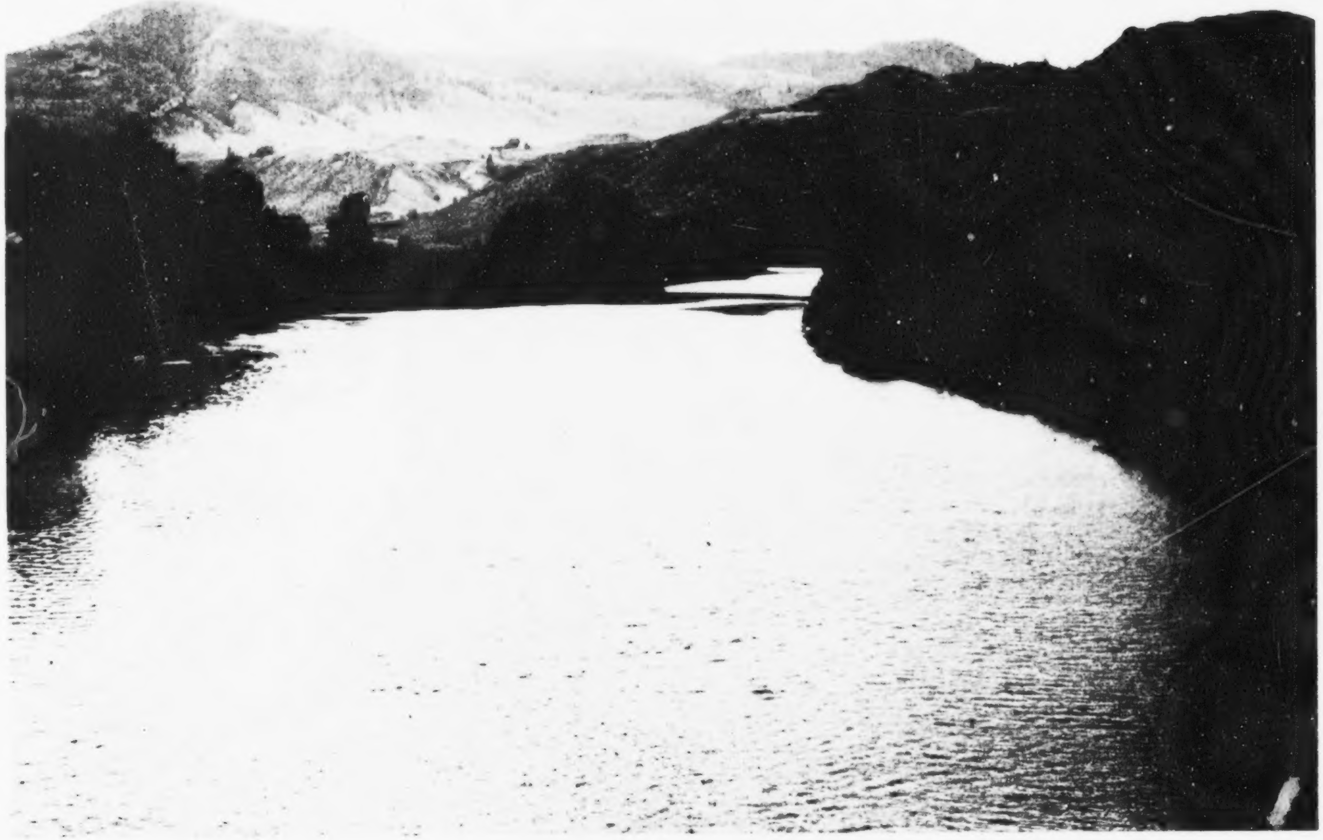
Because of a close time schedule, the field investigation could not be continued at that time. It is anticipated that, in order to locate a thermograph at a representative location on this River, sites several miles farther upstream would have to be investigated.

Further investigations will be necessary before a site on the Okanogan River can be recommended.



BRIDGE OVER OKANOGAN RIVER NEAR MALOTT, WASHINGTON

FIGURE 23



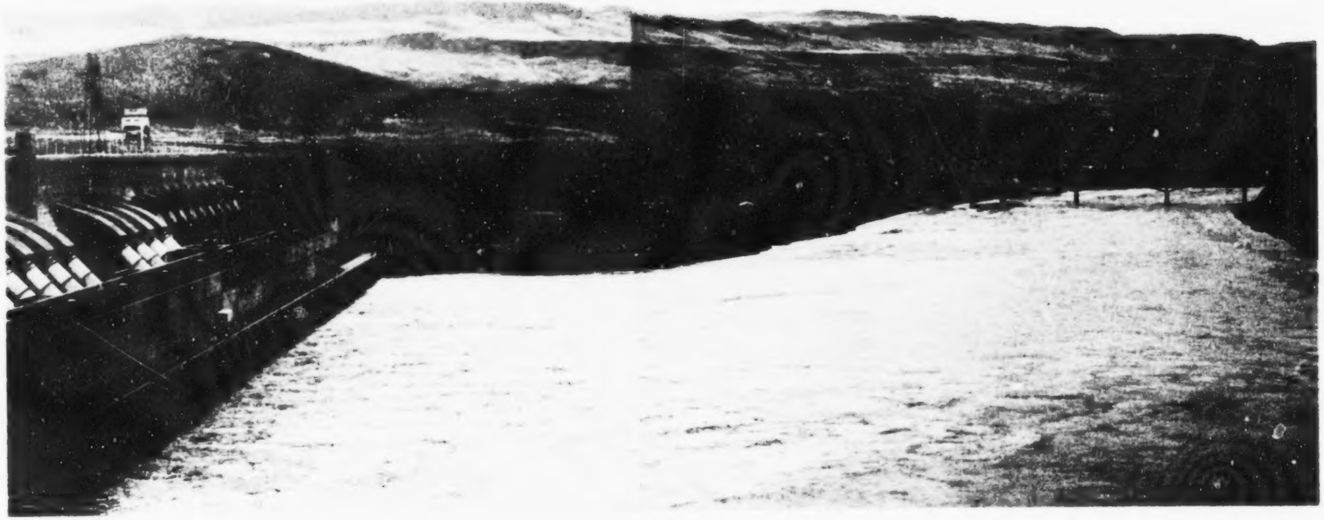
OKANOGAN RIVER NEAR MALOTT, WASHINGTON
Looking downstream from bridge
FIGURE 24

CHIEF JOSEPH DAM (Site No. 32)

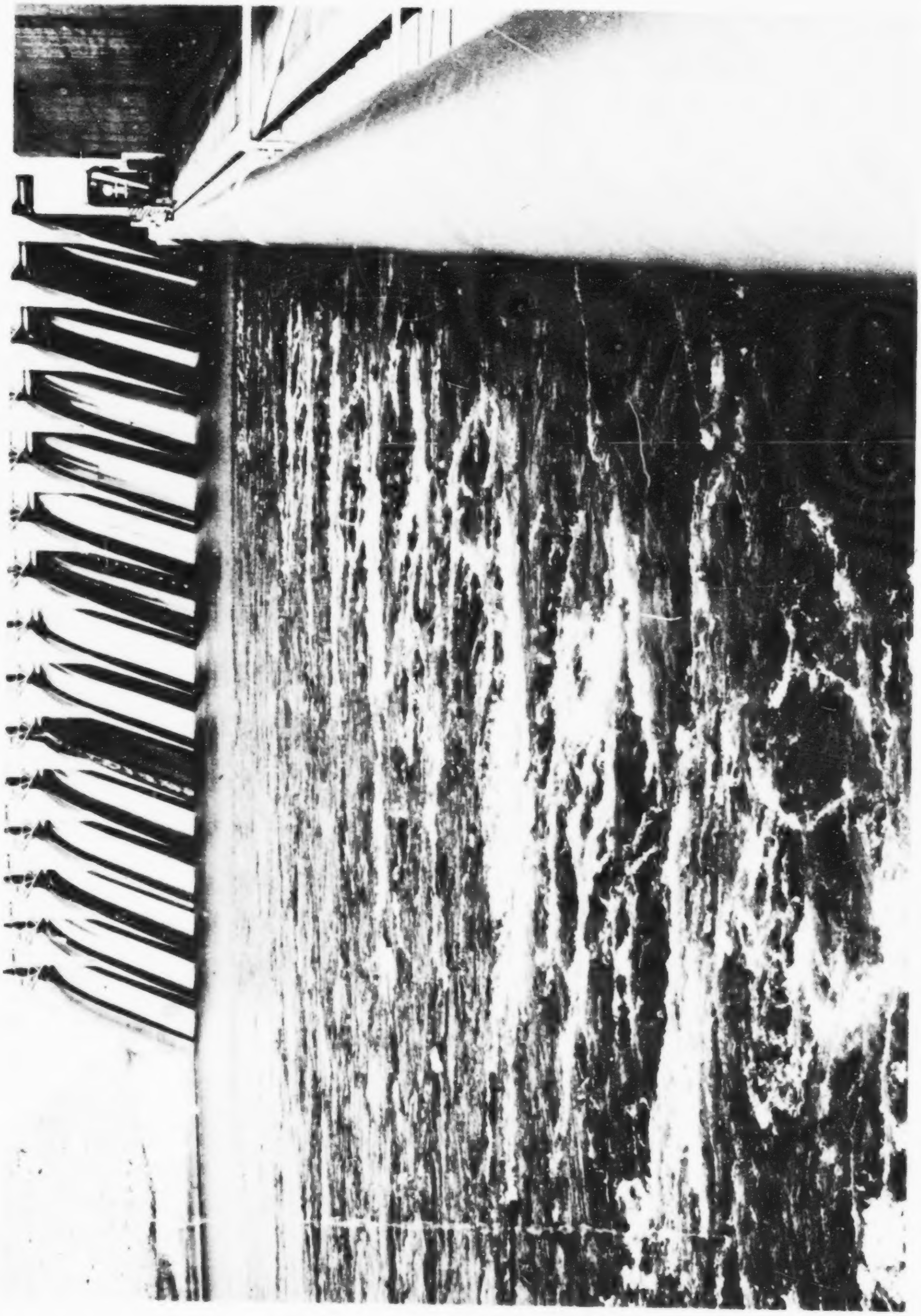
Two thermograph locations were investigated below Chief Joseph Dam and are shown in FIGURE 25. The first location was the dam tailrace (see FIGURE 26) which was completely mixed. Instrumentation can be placed on either end of the tailrace deck so that it will not interfere with the gantry crane operation. The second location is at the bridge just downstream of the dam. Columbia River discharge beneath the bridge was also well mixed so that the thermistor placed in the flowing water will give a representative temperature of the river. The thermograph would be attached to the bridge.

The tailrace location affords less potential vandalism than does the bridge. The proposed expansion of the powerhouse facilities from the present number of turbines (16) to a total of fifty-two would jeopardize the bridge location during both construction and operation.

Temperature measurements are presently being read from a thermometer installed in the turbine cooling water lines. Since project personnel are depended upon to read temperatures, continuous records cannot be obtained. Therefore, a thermograph at the tailrace location appears to be preferable.



COLUMBIA RIVER BELOW CHIEF JOSEPH DAM
Looking at the dam tailrace and the downstream bridge (Q=102,000 cfs)
FIGURE 25

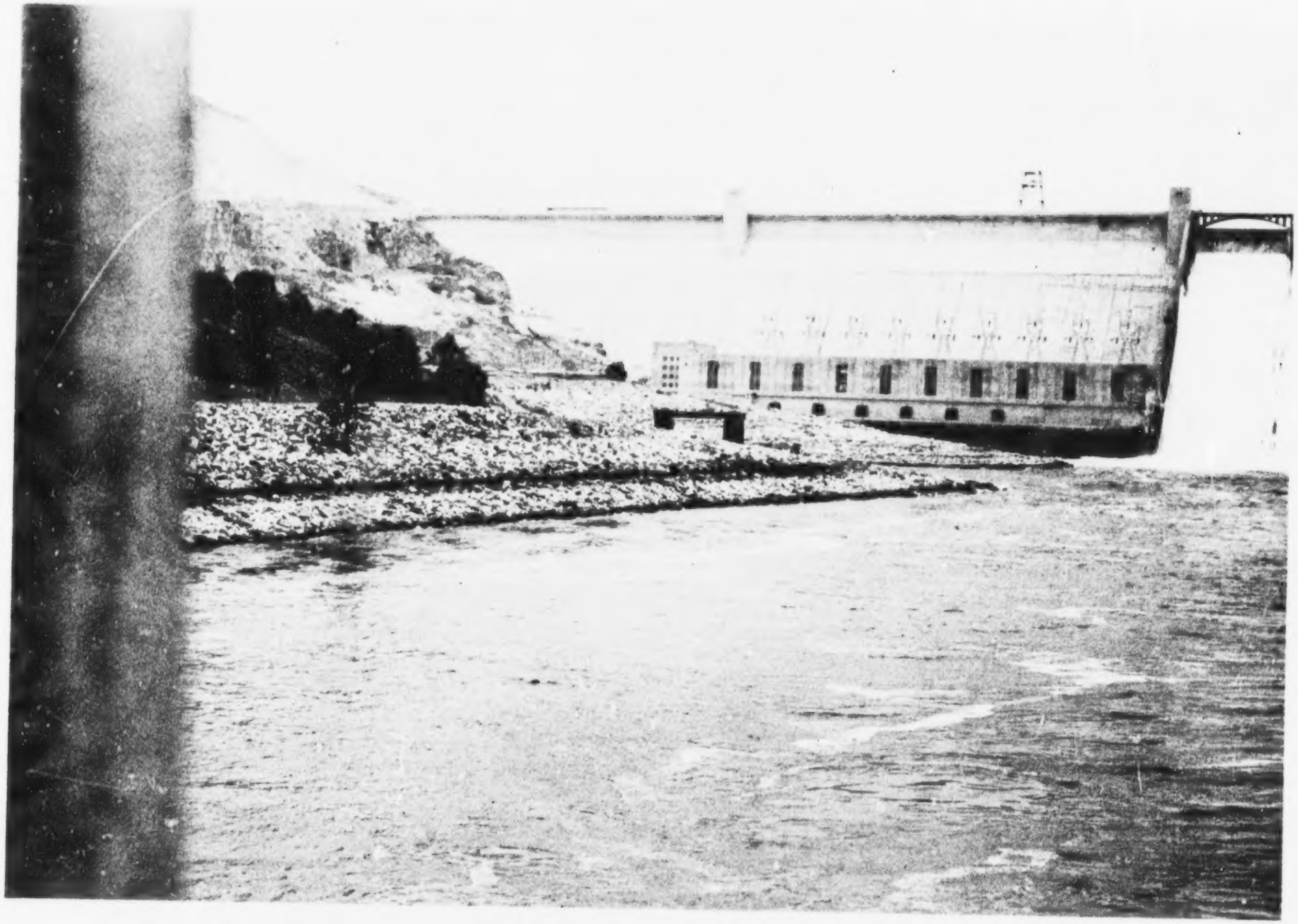


CHIEF JOSEPH DAM
Looking north across tailrace toward right abutment (Q=102,000 cfs)
FIGURE 26

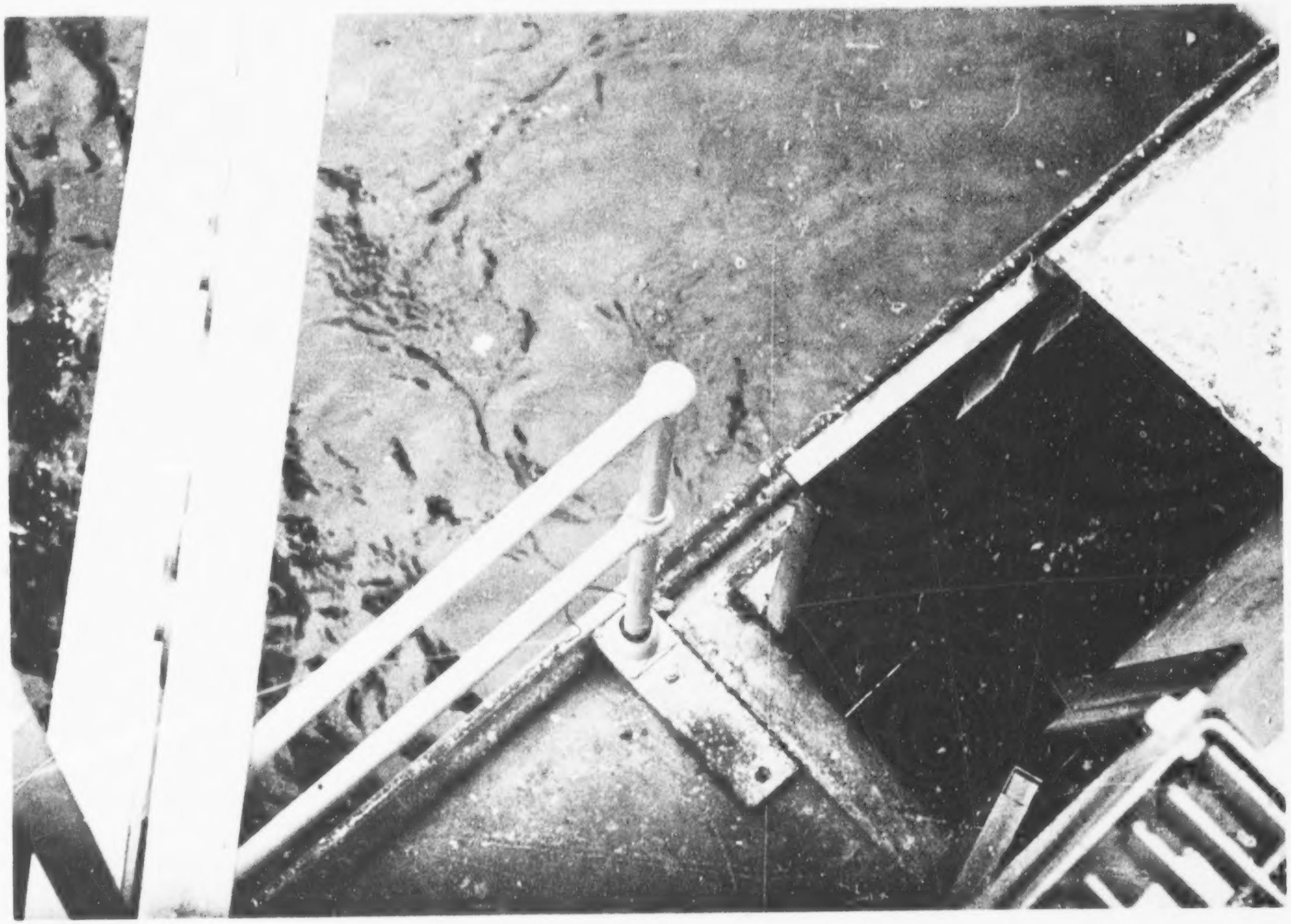
GRAND COULEE DAM (Site No. 33)

Due to the construction of the third powerhouse, extreme turbulence in the tailrace and frequent warmer water released through the spillway gates , it is felt that the best location at Grand Coulee Dam will be at the highway bridge just downstream of the dam. FIGURE 27 shows the right bank just below the dam where construction of the third powerhouse is proceeding. The photograph is taken from the proposed thermograph location on top of the left bridge pier. FIGURE 28 shows the protected, project-owned, compartment on top of the bridge pier which can house the thermograph. The thermistor and lead would hang down along the pier and into the moving water.

Battelle Northwest has recently placed a Foxboro thermograph on this bridge. This thermograph should be adequate for the initial stage of the network, but if vandalism interrupts its operation, an instrument should be installed in the bridge pier compartment previously described.



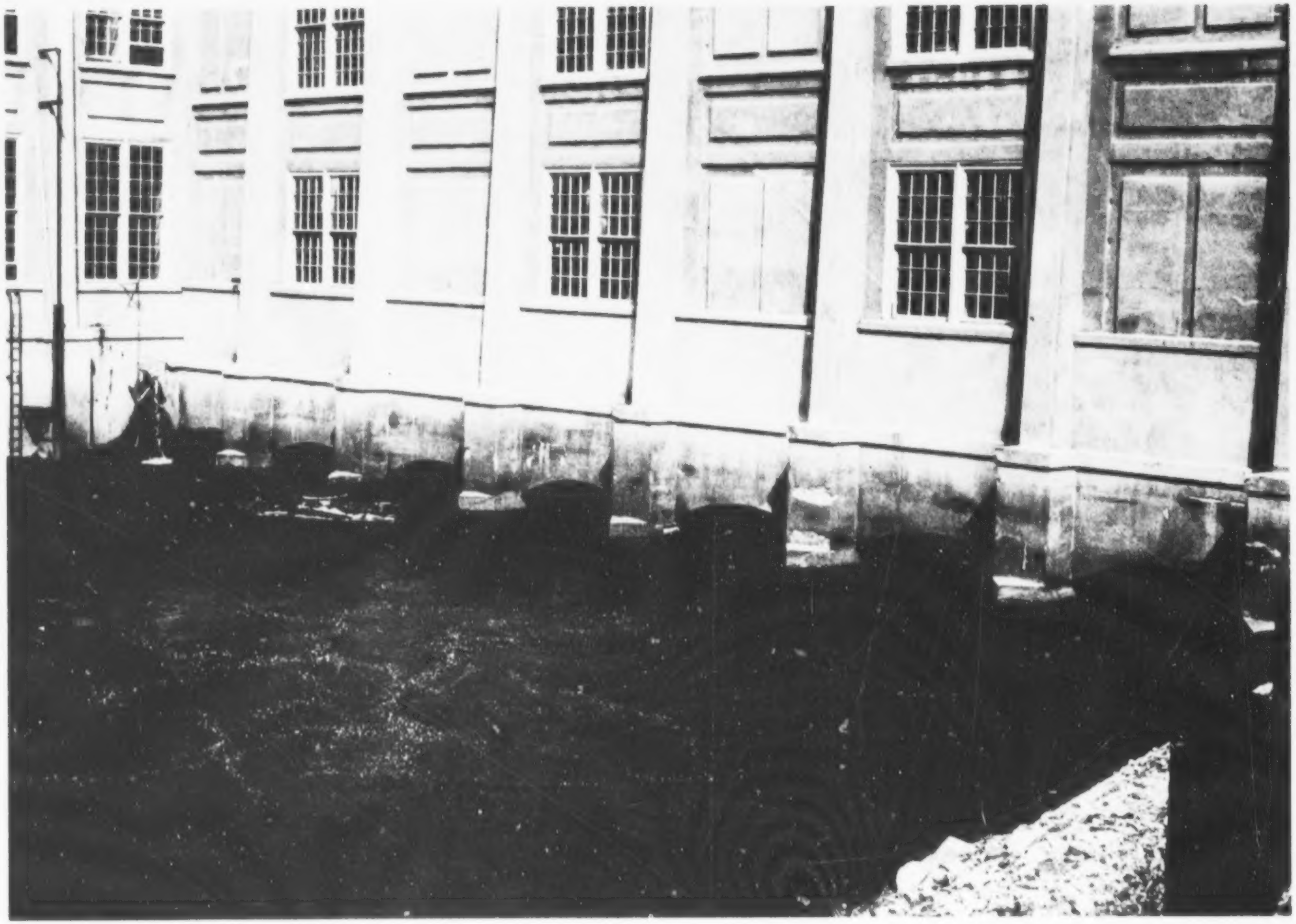
GRAND COULEE DAM
Looking upstream from bridge at right bank of dam (Q=99,000 cfs)
(Note: third powerhouse will be constructed in this area)
FIGURE 27



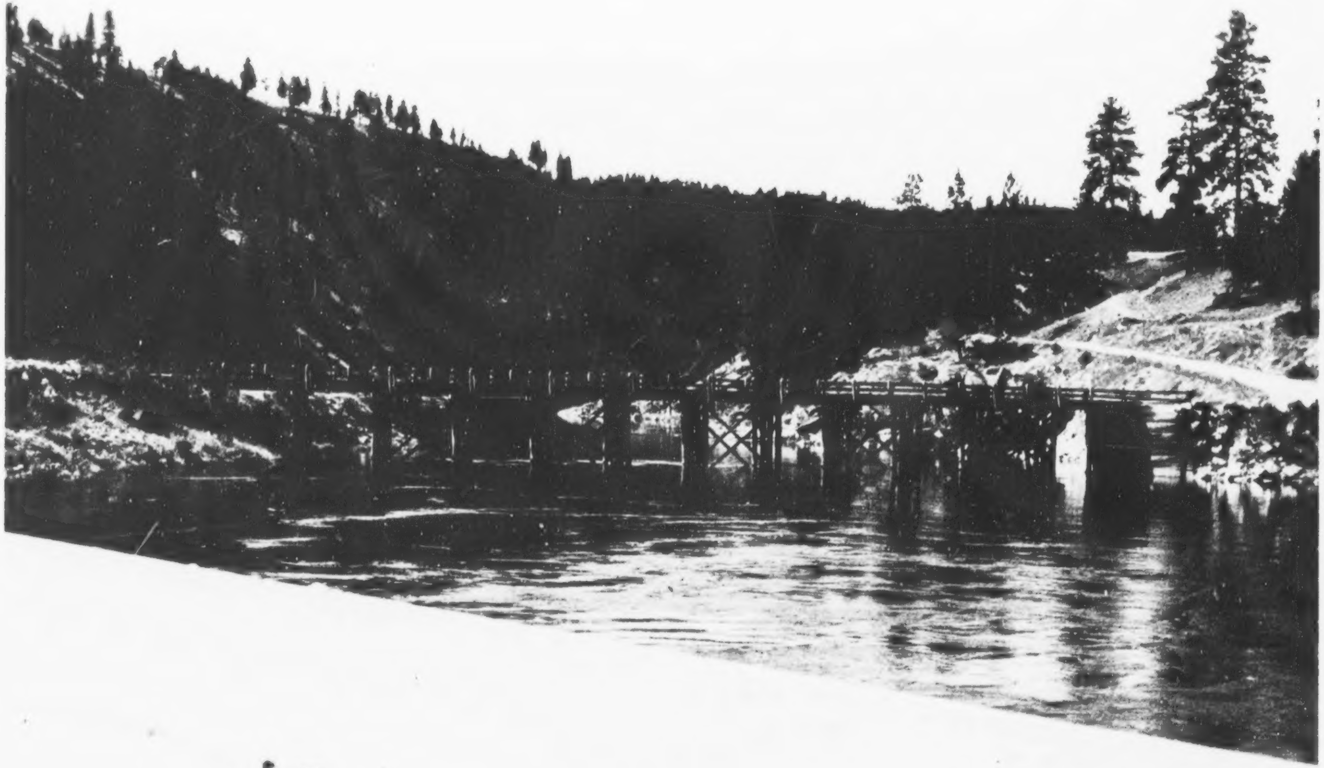
BRIDGE DOWNSTREAM OF GRAND COULEE DAM
Looking at instrument compartment on top of left pier
FIGURE 28

SPOKANE RIVER (Site No. 34)

As part of the RTRN "minimum list" a thermograph should be placed on the Spokane River, a main tributary to the Columbia River above Grand Coulee Dam. Lake Roosevelt causes slack water conditions (vertical temperature stratification) in the Spokane River upstream to Little Falls Dam. Therefore, temperatures taken downstream of the Little Falls Dam turbulent tailrace may not be representative of the Spokane River conditions. FIGURE 29 shows the powerhouse and tailrace of Little Falls Dam. The tailrace is well mixed immediately below the dam and appears to be an adequate location for a thermograph. FIGURE 30 shows the wooden bridge just downstream of the Little Falls Dam tailrace. If the bridge location is selected, temperature cross-sections would have to be taken prior to thermograph installation and a protective housing provided to reduce potential vandalism.



LITTLE FALLS DAM - SPOKANE RIVER
Looking upstream at powerhouse and tailrace (Q=4000 cfs)
FIGURE 29

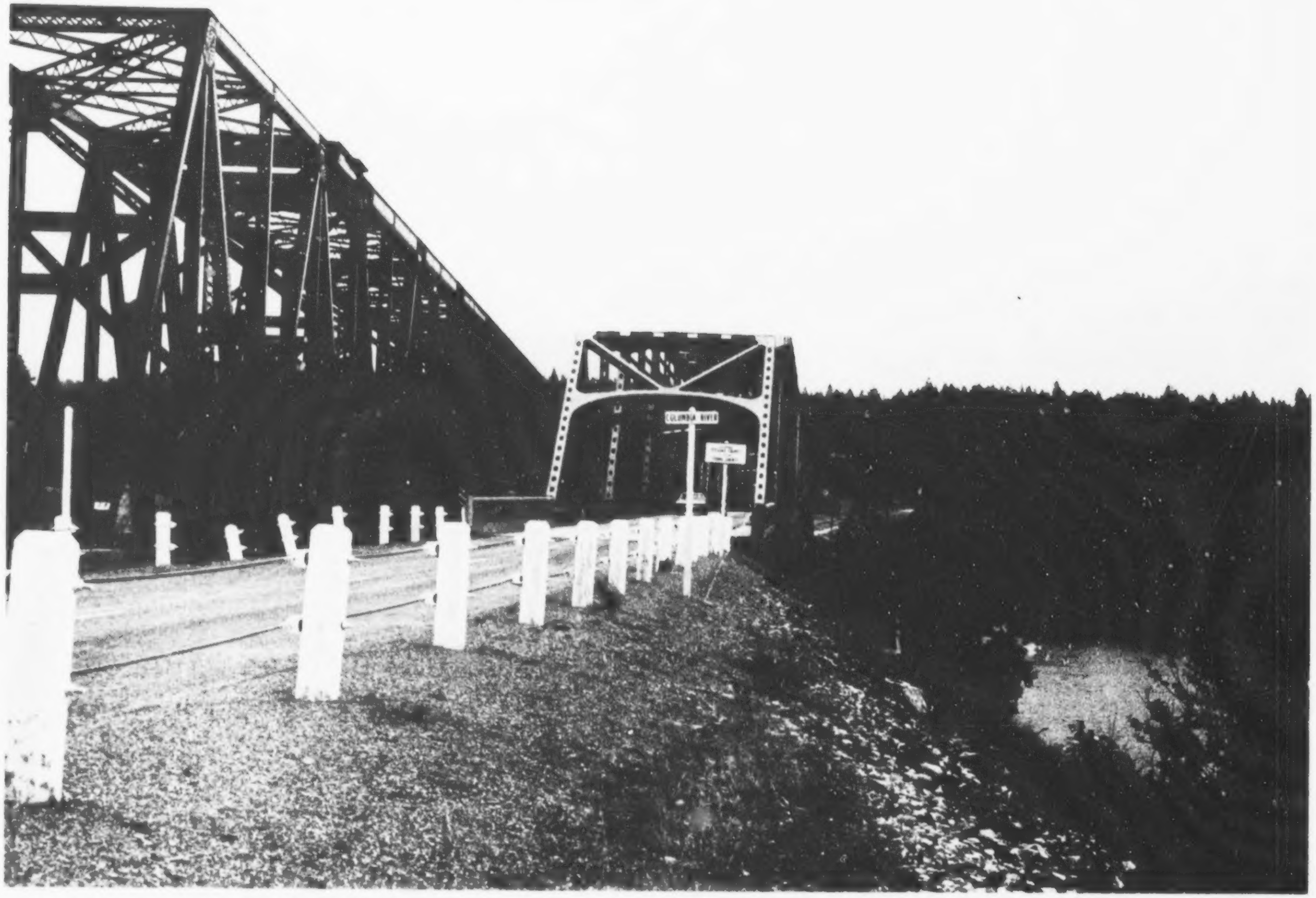


BRIDGE OVER THE SPOKANE RIVER JUST DOWNSTREAM OF LITTLE FALLS DAM
Photograph taken on Aug. 26, 1968 from the left bank tailrace wall (Q=4000 cfs)
FIGURE 30

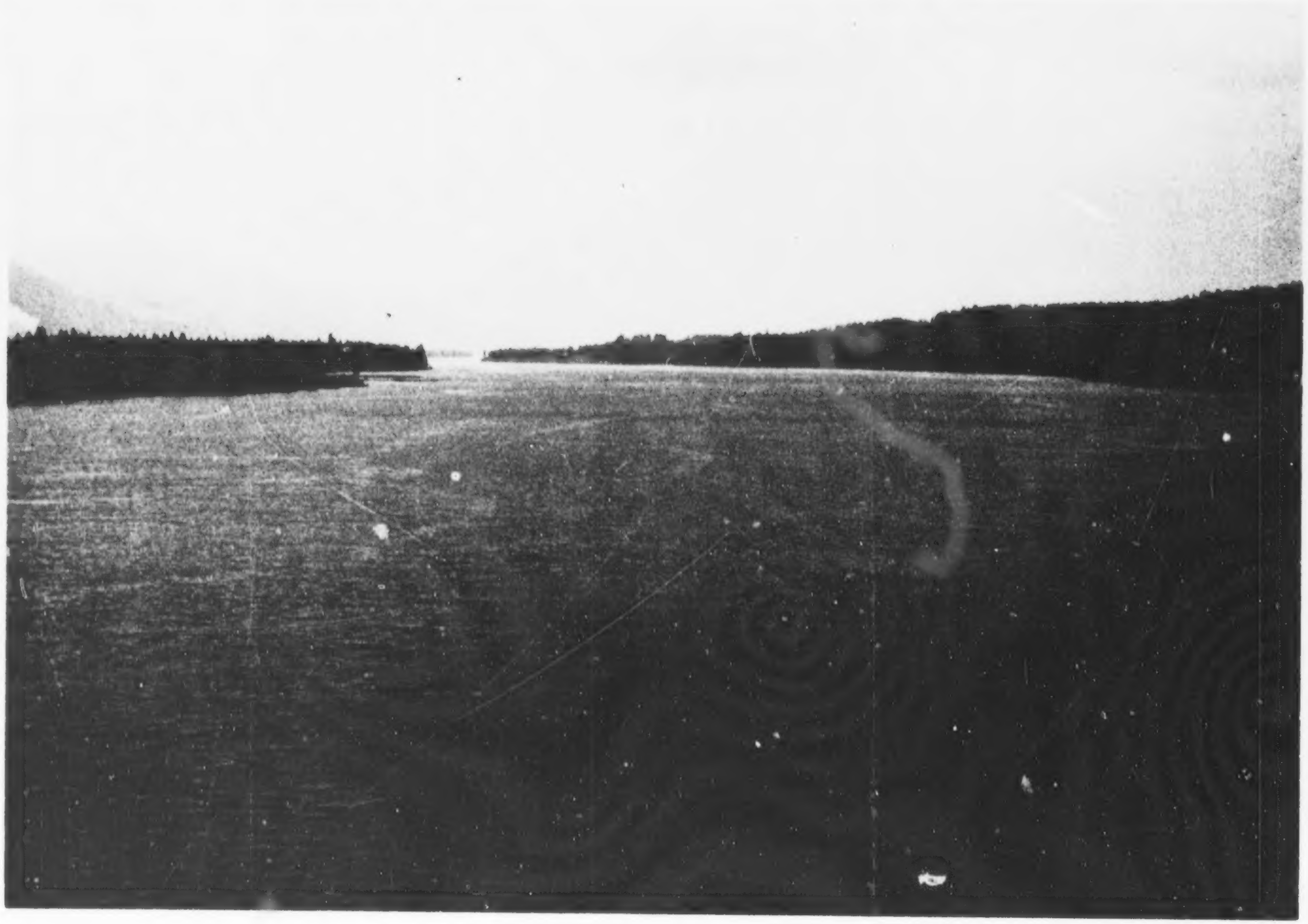
COLUMBIA RIVER NEAR U.S. - CANADIAN BORDER (Site No. 35)

Two thermograph sites were investigated close to the United States-Canada border. The old 395 highway bridge, shown in FIGURE 31, over the Columbia River near Kettle Falls, Washington was investigated as a possible thermograph location. FIGURE 32 shows the river condition downstream of the bridge. As shown on photograph 32, the river is still affected by backwater of Lake Roosevelt and may be stratified during part of the year, although Battelle Northwest presently is operating a Foxboro thermograph there. Temperature measurements made on August 23, 1968 indicated that the river was slightly stratified at that time.

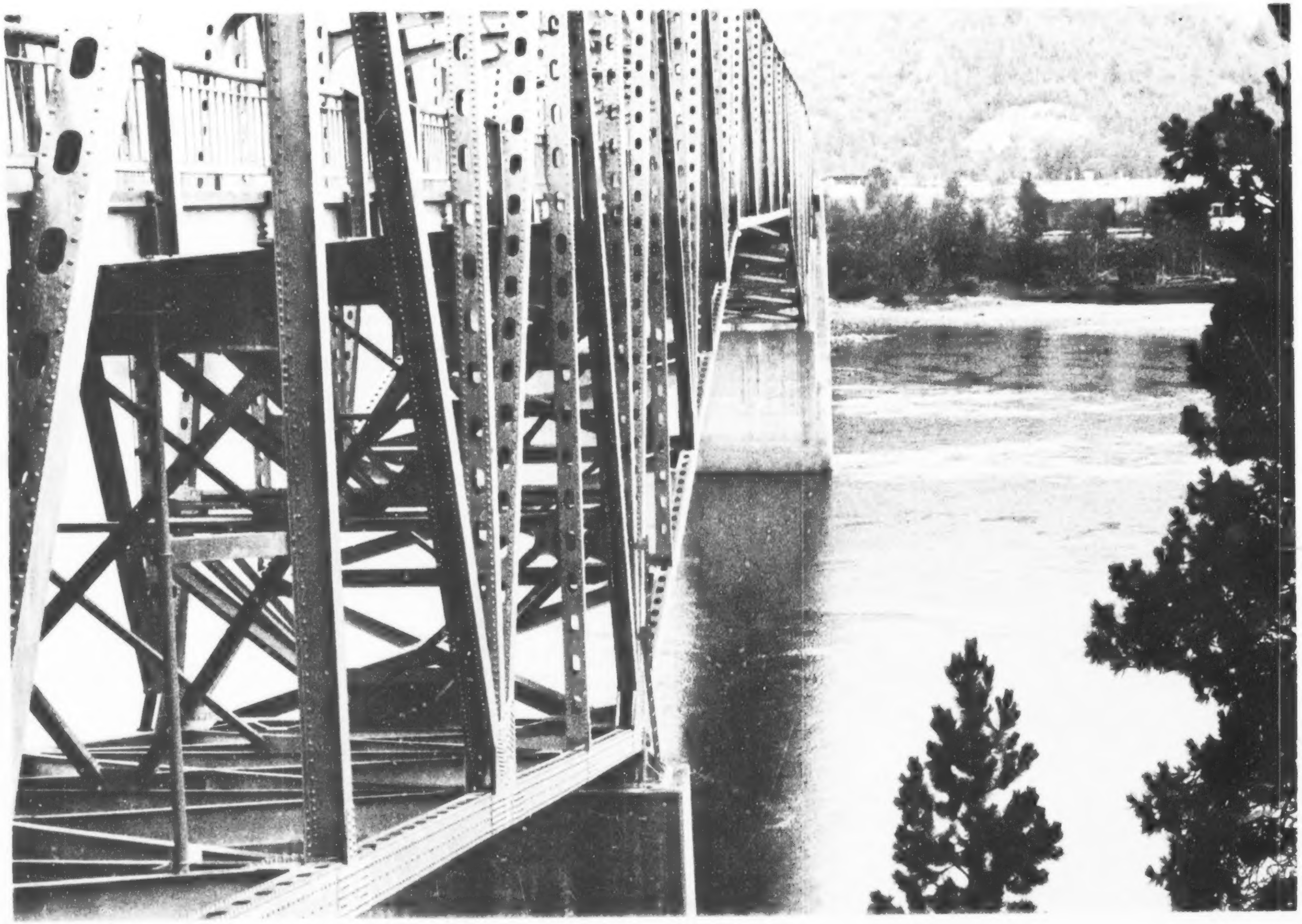
The bridge crossing the Columbia River at Northport, Washington (FIGURE 33) is a good location for a continuous recording thermograph. There is a moderate current past this location as can be seen from FIGURE 34 in contrast to the ponded river condition at Kettle Falls. Battelle Northwest under contract to AEC has installed a Foxboro thermograph on this bridge (see FIGURE 35) which should be satisfactory for the temperature reporting network. Temperature cross-sections taken on August 23, 1968, during the reconnaissance field trip indicated a well mixed river condition. Comparison of results from the two existing thermographs showed that temperatures at Kettle Falls were considerably greater than at Northport.


COLUMBIA RIVER

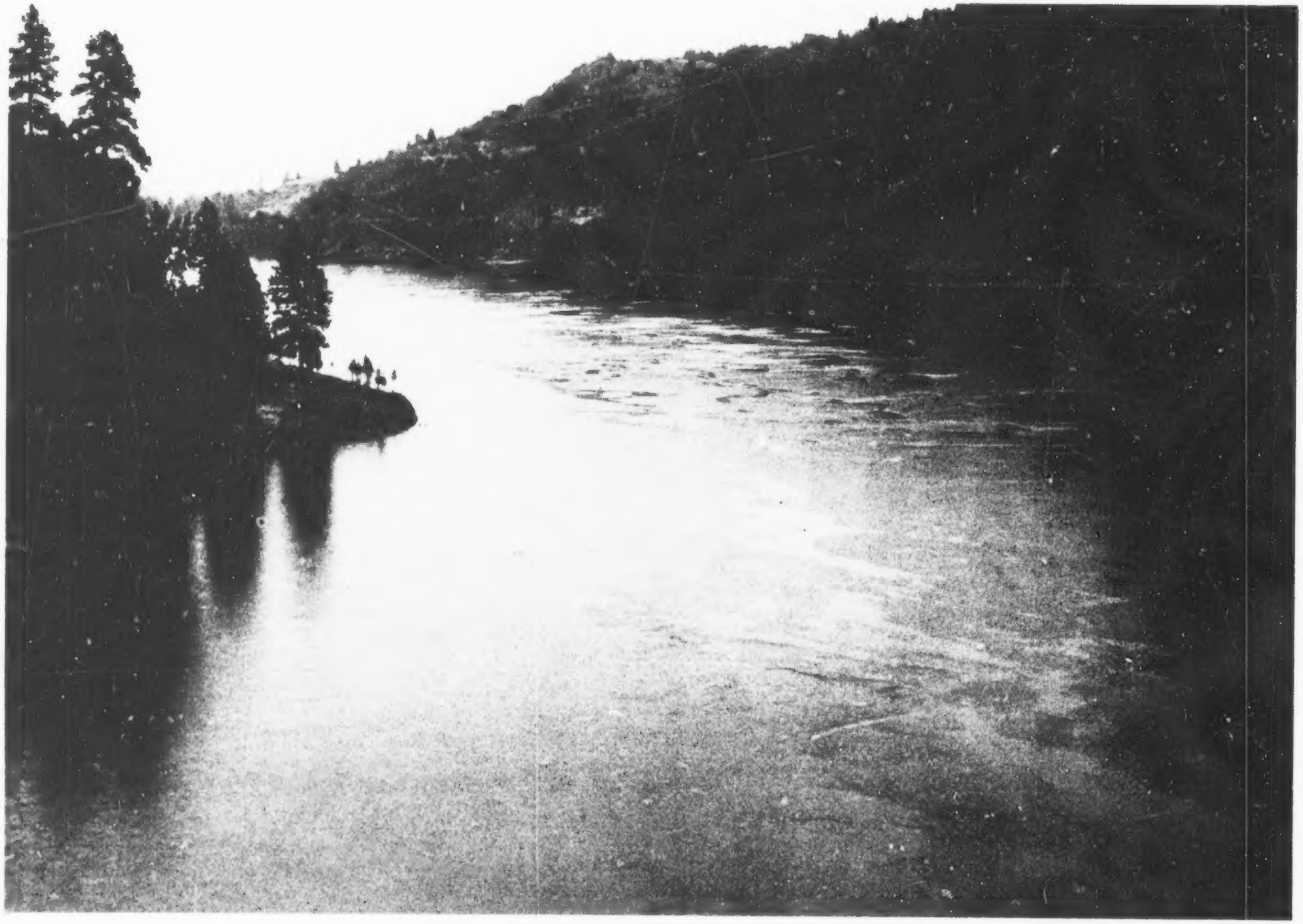
HIGHWAY 395 BRIDGE OVER THE COLUMBIA RIVER AT
KETTLE FALLS, WASHINGTON
FIGURE 31



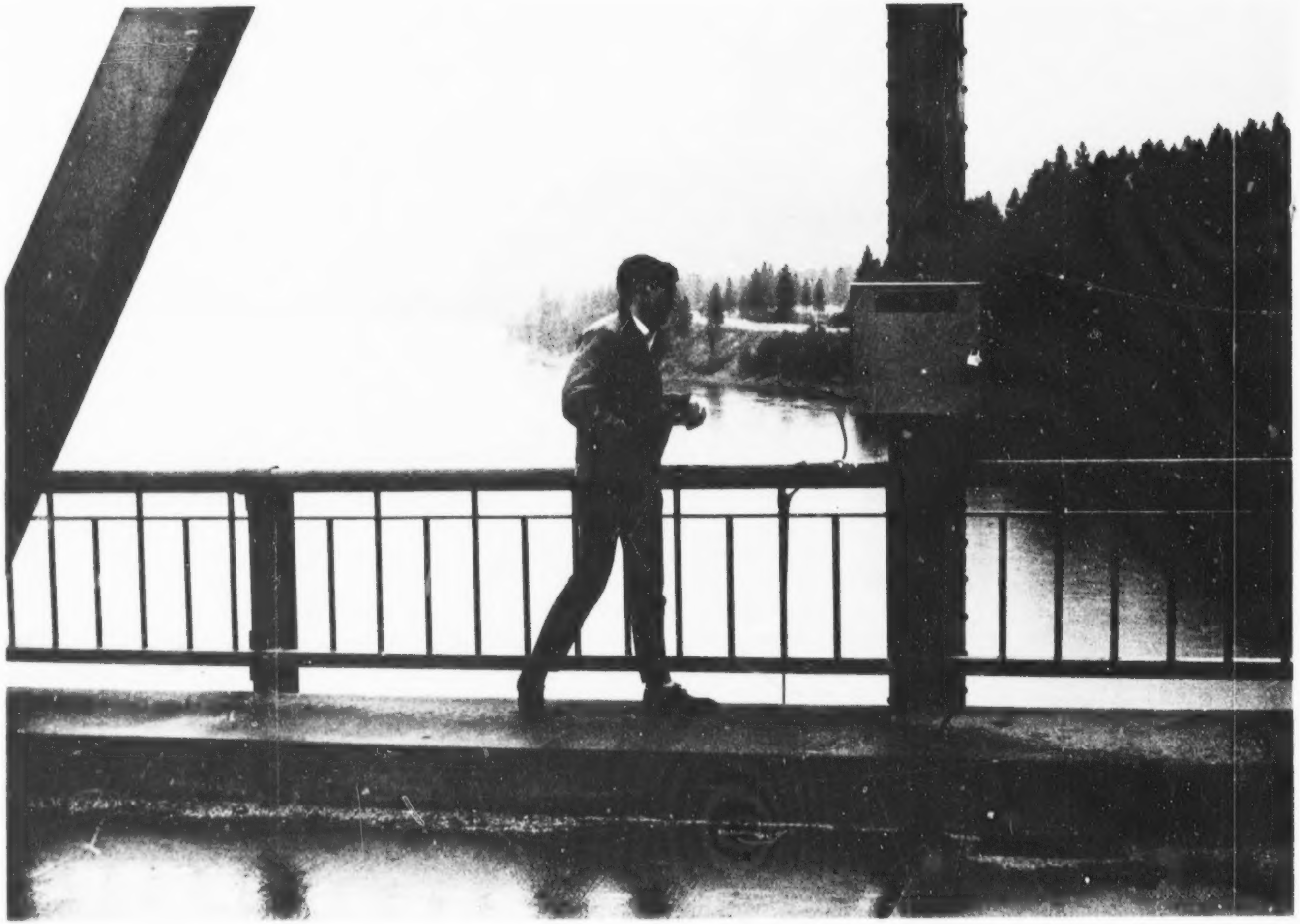
COLUMBIA RIVER AT KETTLE FALLS, WASHINGTON
Looking downstream from Highway 395 bridge
FIGURE 32



BRIDGE OVER COLUMBIA RIVER AT NORTH PORT, WASHINGTON
Looking toward left bank of river
FIGURE 33



COLUMBIA RIVER AT NORTH PORT, WASHINGTON
Looking upstream (North)
FIGURE 34



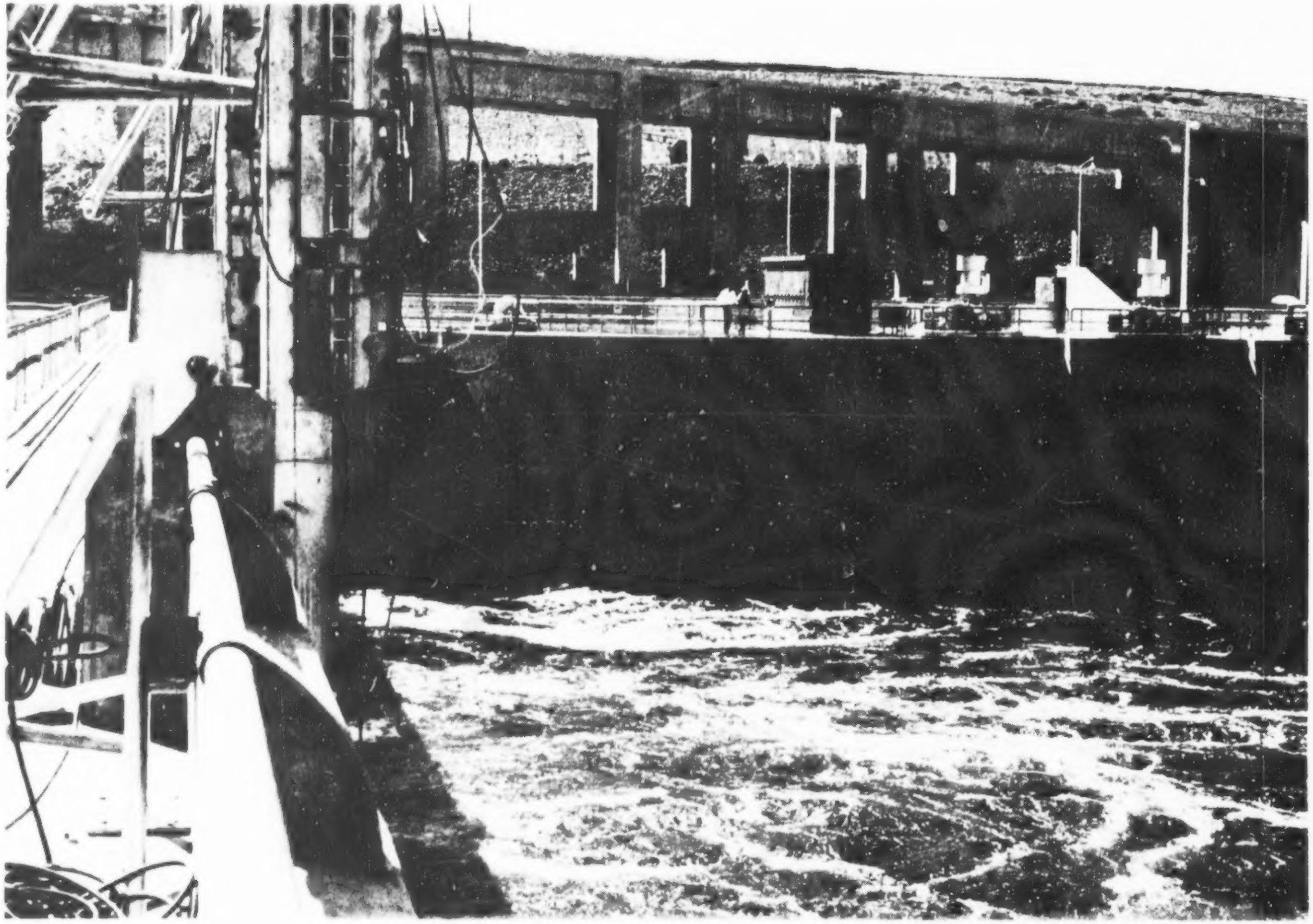
COLUMBIA RIVER BRIDGE AT NORTH PORT, WASHINGTON
View of existing thermograph housing at downstream side of bridge
FIGURE 35

ICE HARBOR DAM (Site No. 41)

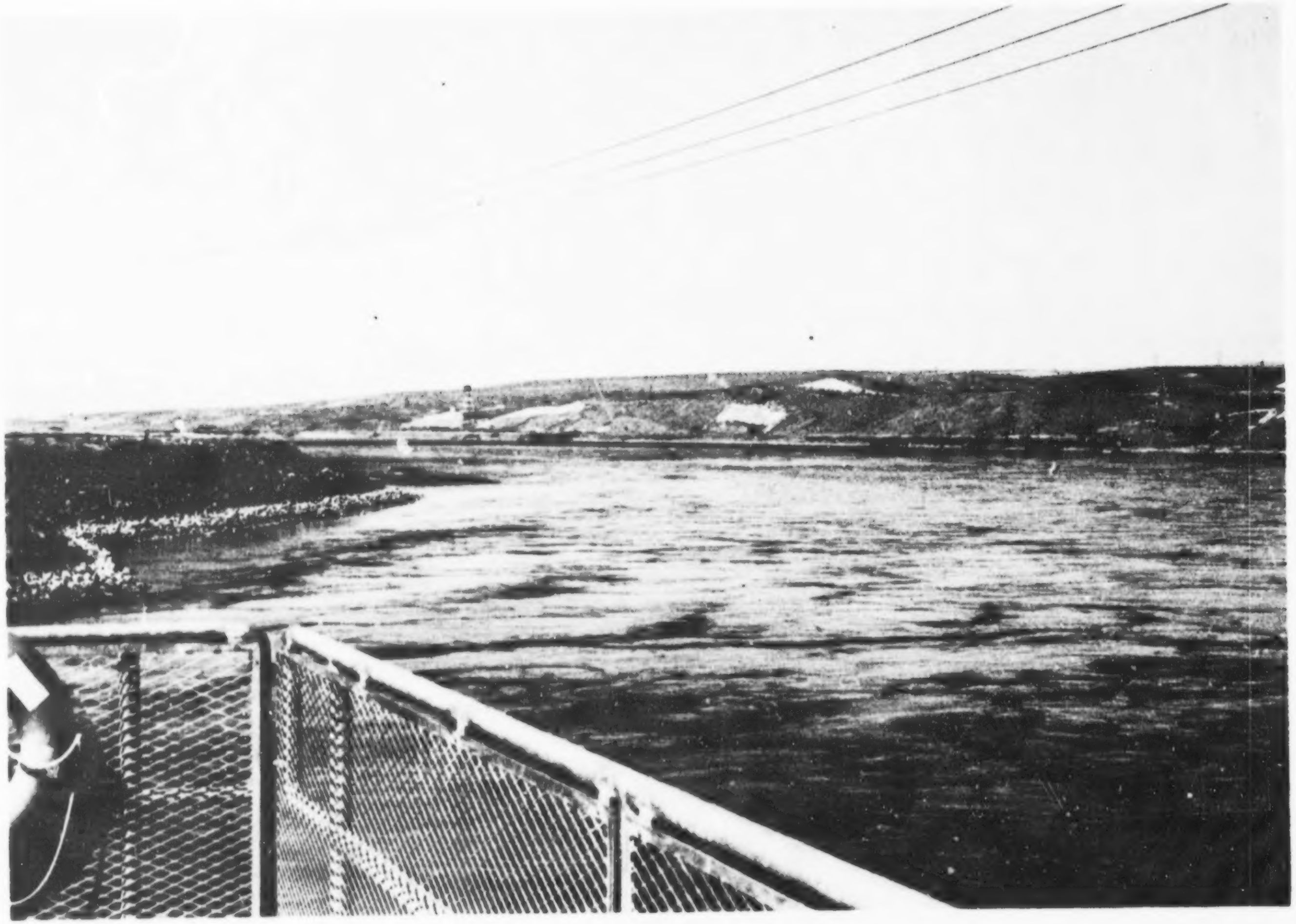
The tailrace of Ice Harbor Dam apprears to be an ideal location for a thermograph because of the completely mixed discharge from the dam. Stratified river conditions were documented further downstream during the reconnaissance survey. This stratification was caused by warmer Snake River water overriding the colder backwater from McNary pool.

FIGURE 36 shows a probable location for the continuous recording thermograph which is on the left side of the tailrace, approximately where the men shown in the photograph are standing. FIGURE 37 shows the turbulent river condition downstream of the potential thermograph location.

Temperature readings are presently being taken from a thermometer attached to the turbine cooling water lines. These records are not adequate for incorporation into the RTRN as discussed in earlier paragraphs.



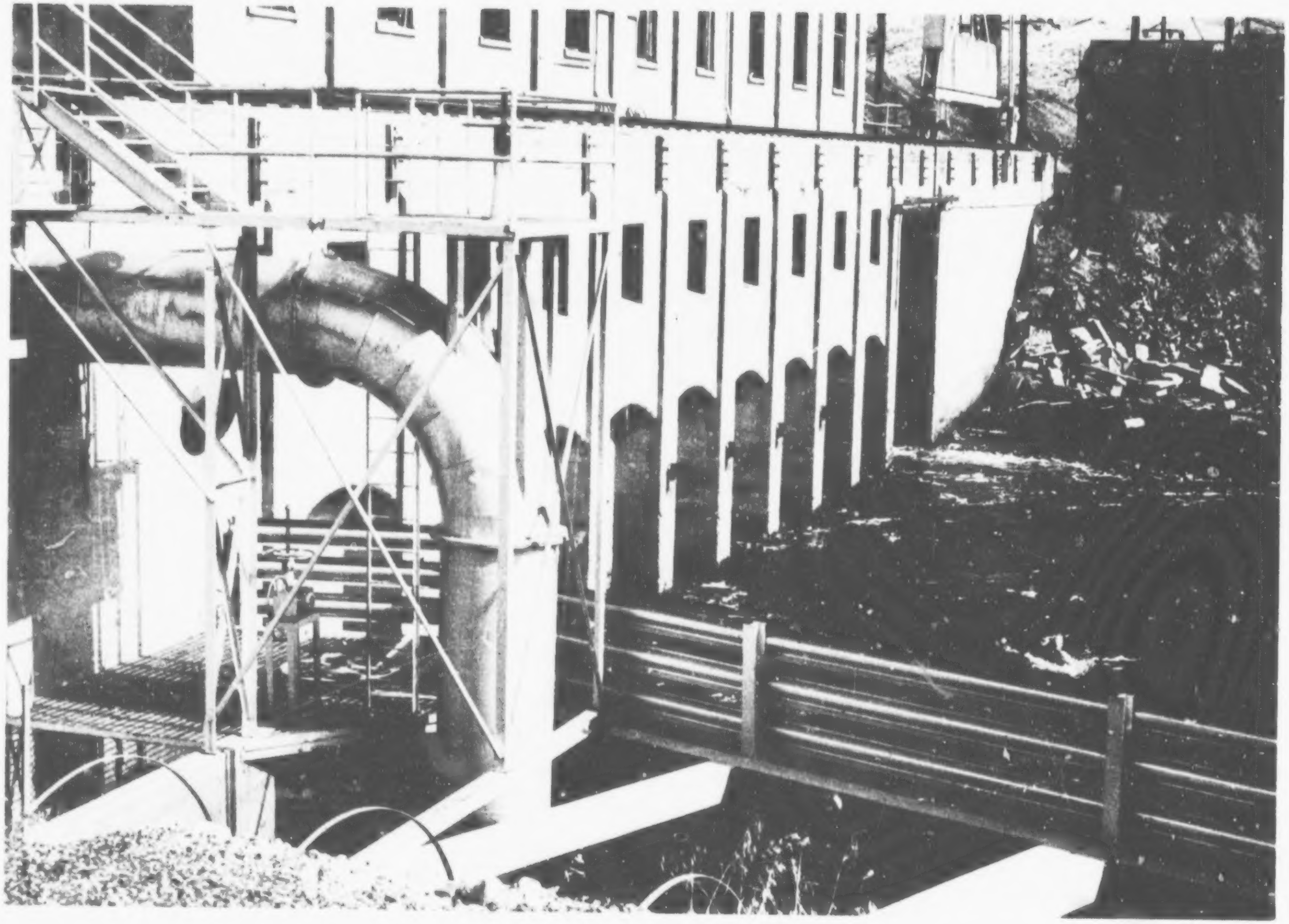
ICE HARBOR DAM - SNAKE RIVER
Looking at tailrace and left wall downstream of powerhouse (Q=37,000 cfs)
FIGURE 36



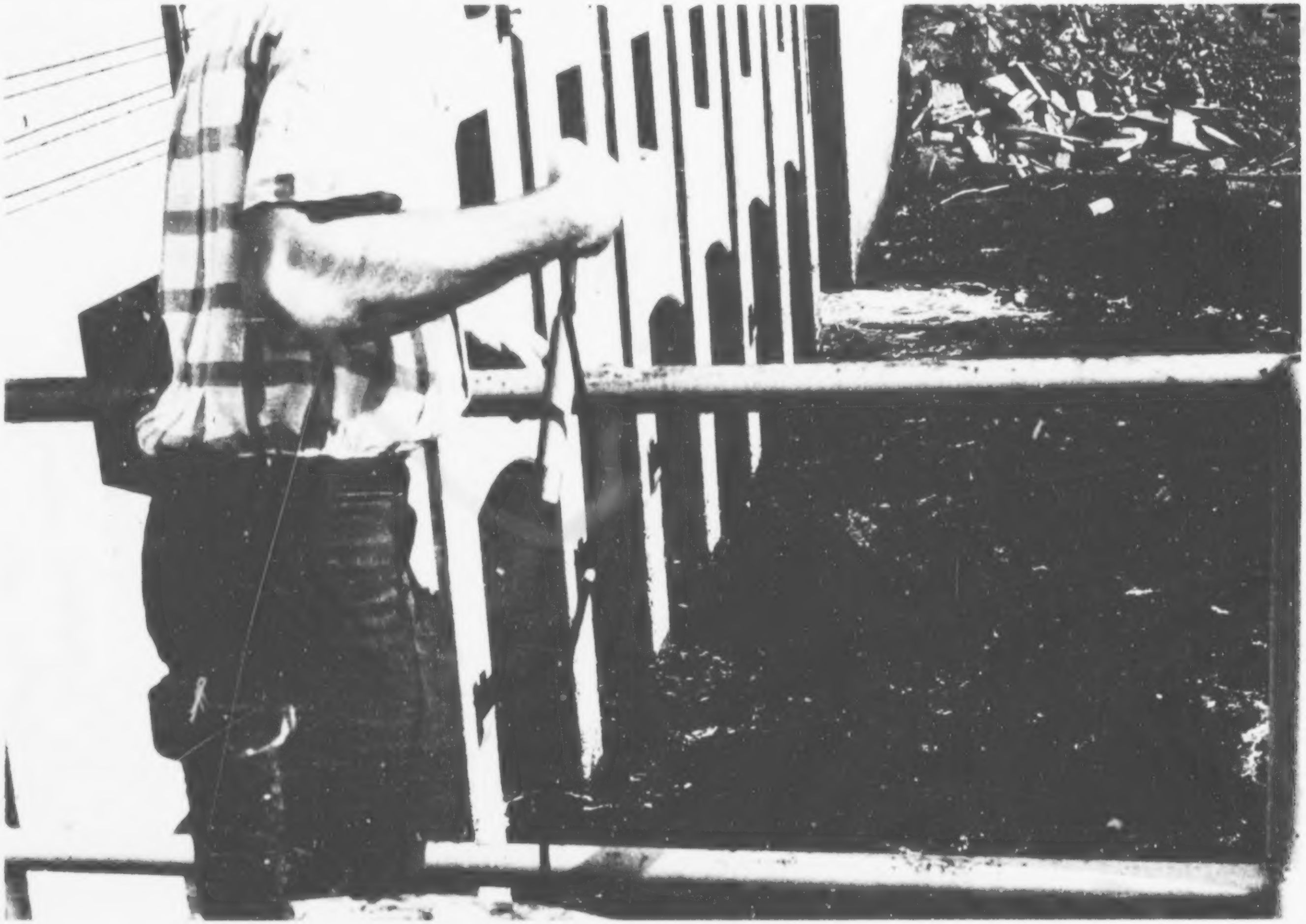
SNAKE RIVER DOWNSTREAM OF ICE HARBOR DAM
Looking at turbulent tailrace from left side of Dam (Q=37,000 cfs)
FIGURE 37

CLEARWATER RIVER (Site No. 46)

Washington Water Power Dam is located on the Clearwater River approximately 4.6 miles upstream of its confluence with the Snake River. Temperatures taken from a thermograph located downstream of the dam would be of doubtful value due to the unknown effect of the backwater at this dam caused by Lower Granite Dam now under construction. According to the project manager, backwater effects on turbine efficiencies may cause closure of the Washington Water Power Dam Operation. If the decision is made to install a thermograph here prior to the completion of Lower Granite Dam, the best thermograph sensor location would be in the tailrace with the recorder attached to the right bank platform shown in FIGURES 38 & 39. A thermistor placed in the tailrace will have to be protected from the constant debris accumulation in the turbulent water. One temperature reading per project shift is presently being taken from an old thermometer attached to the turbine cooling water line, but this method of temperature reporting is not acceptable for inclusion into the RTRN.



WASHINGTON WATER POWER DAM - CLEARWATER RIVER, IDAHO
Looking across tailrace toward left bank (Q=3900 cfs)
FIGURE 38

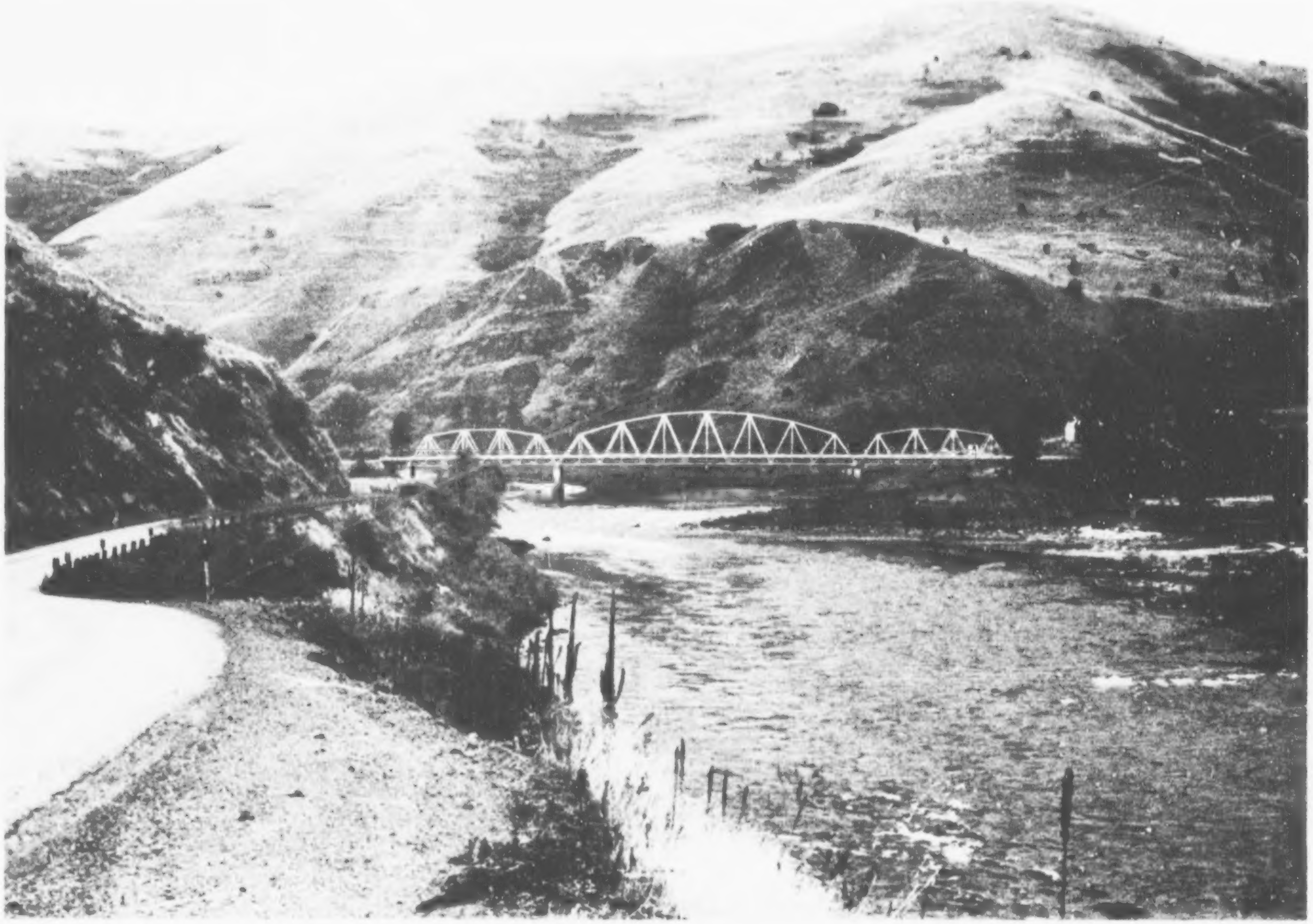


WASHINGTON WATER POWER DAM
Looking at tailrace from platform on right bank (Q=3,900 cfs)
FIGURE 39

SALMON RIVER (Site No. 49 & 50)

It is desirable to install a thermograph far enough upstream on the Salmon River to be out of the Snake River backwater influence. Site access is poor near the Salmon River mouth due to the lack of roads; therefore, the potential location was not investigated at that time. The Boise, Idaho office of U.S.G.S. plans to install a complete water quality station here in the near future. U.S.G.S. will be contacted regarding this station to explore the possibility of incorporating an RTRN thermograph into it.

The White Bird site (No. 50) on the Salmon River was investigated. FIGURE 40 shows the highway bridge crossing the Salmon River near White Bird, Idaho, just upstream of a U.S.G.S. gaging station. If economical, incorporation of the thermograph into the gaging station would eliminate any vandalism likely to occur in this area. However, temperatures at this site would not be representative of the Salmon River temperature contribution to the Snake River because of its physical location (this reach is historically colder because of shading by canyon walls) and its distance above the confluence (approximately 54 miles).

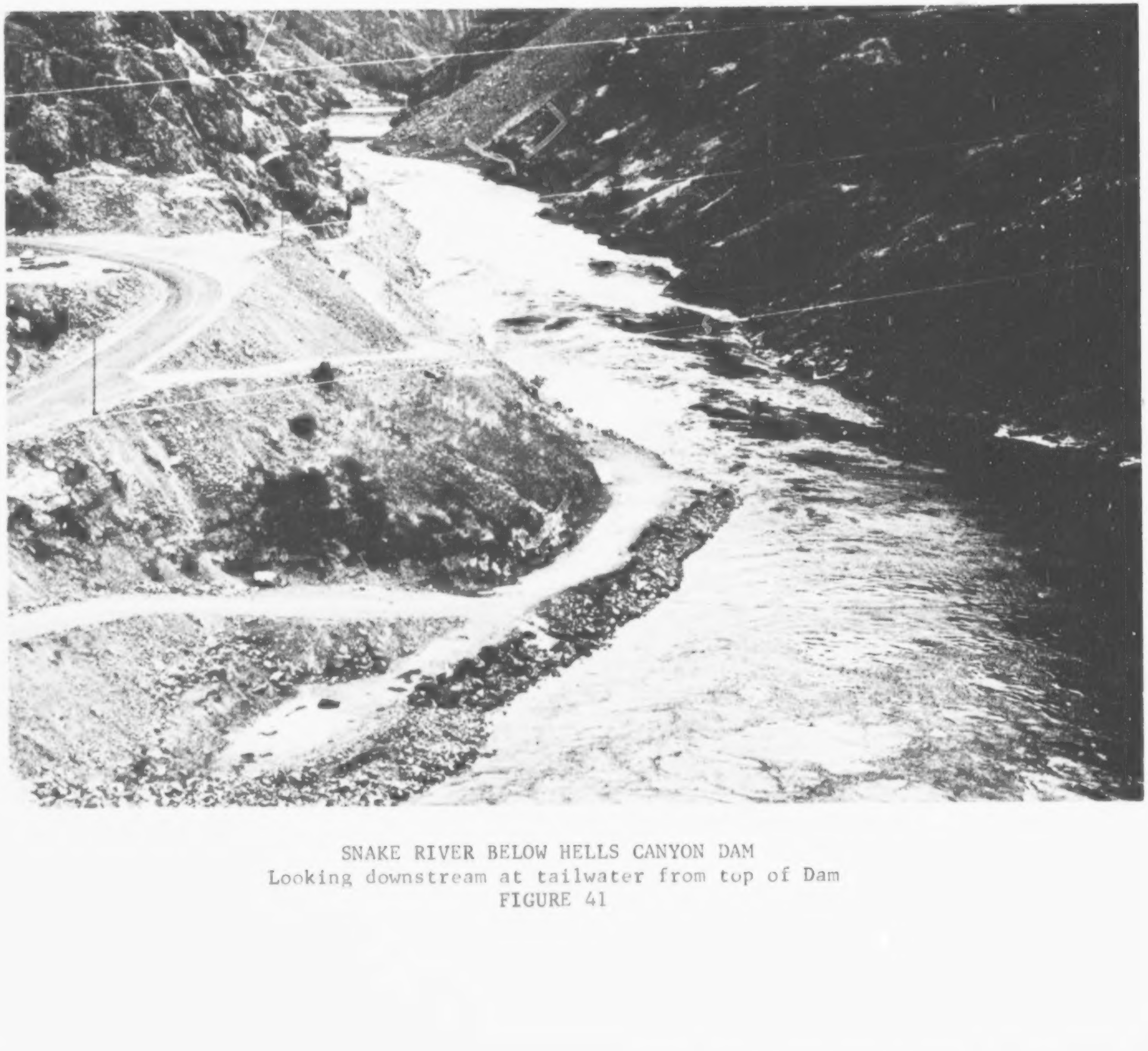


SALMON RIVER AT WHITE BIRD, IDAHO
Looking upstream at bridge from right river bank opposite U.S.G.S. gauging station
FIGURE 40

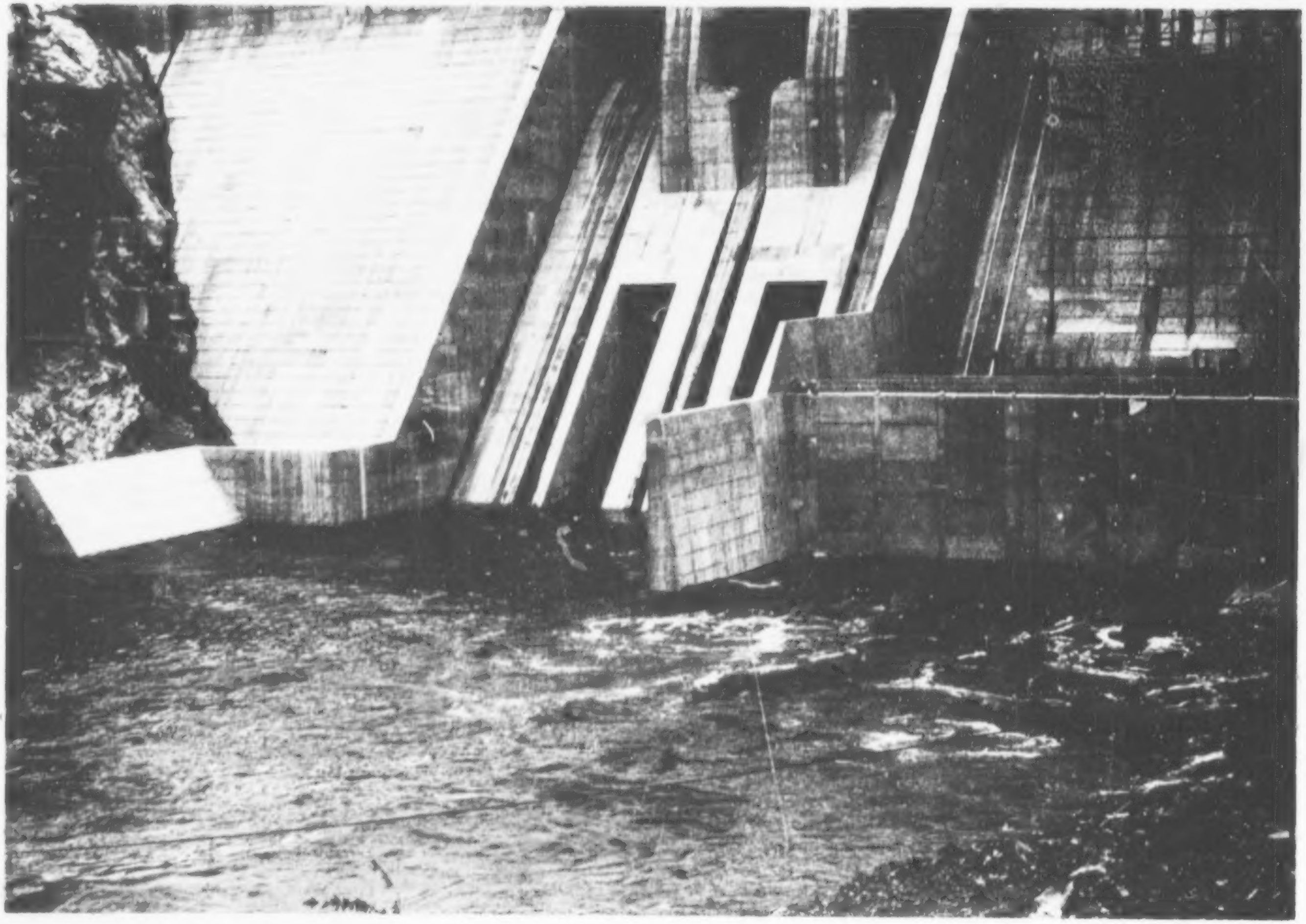
HELLS CANYON DAM (Site No. 53)

Discharge below Hells Canyon Dam is turbulent and swift flowing, as shown in FIGURE 41, leaving little doubt that the river is completely mixed at this location. The lower elevations below the dam are subject to inundation and therefore are not suitable as a year-round thermograph site. The most practical location would be on the tailrace deck of the dam (see FIGURE 32). The specific location would be at the point where the spillway training wall and powerhouse wall intersect.

An FWPCA water quality station was located (August 27, 1968) on the left bank of the river downstream of the dam (see white box in photograph were the land point projects into the river). The station has subsequently been removed.



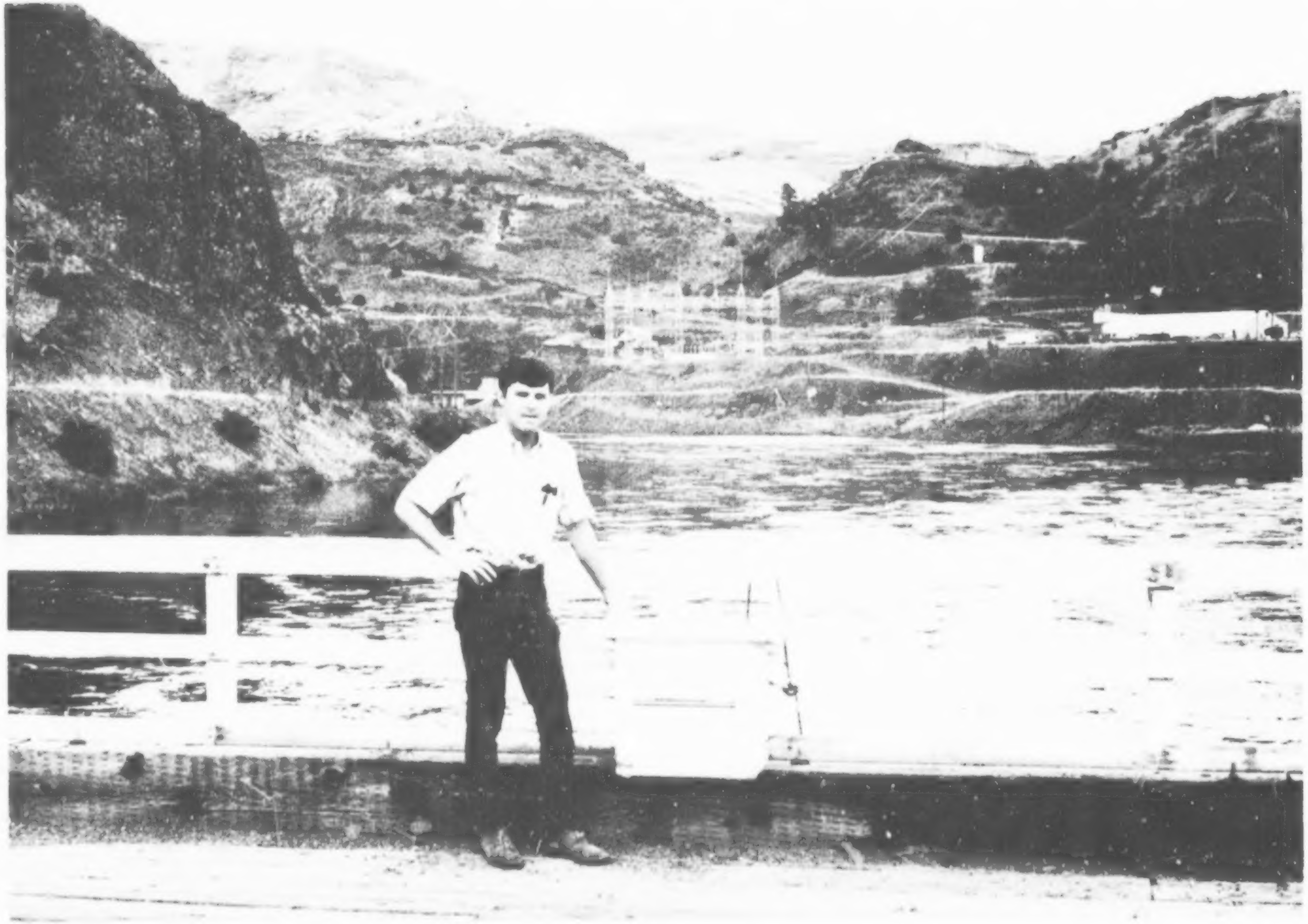
SNAKE RIVER BELOW HELLS CANYON DAM
Looking downstream at tailwater from top of Dam
FIGURE 41



HELLS CANYON DAM
Looking upstream at downstream face of Dam
FIGURE 42

OXBOW DAM (Site No. 54)

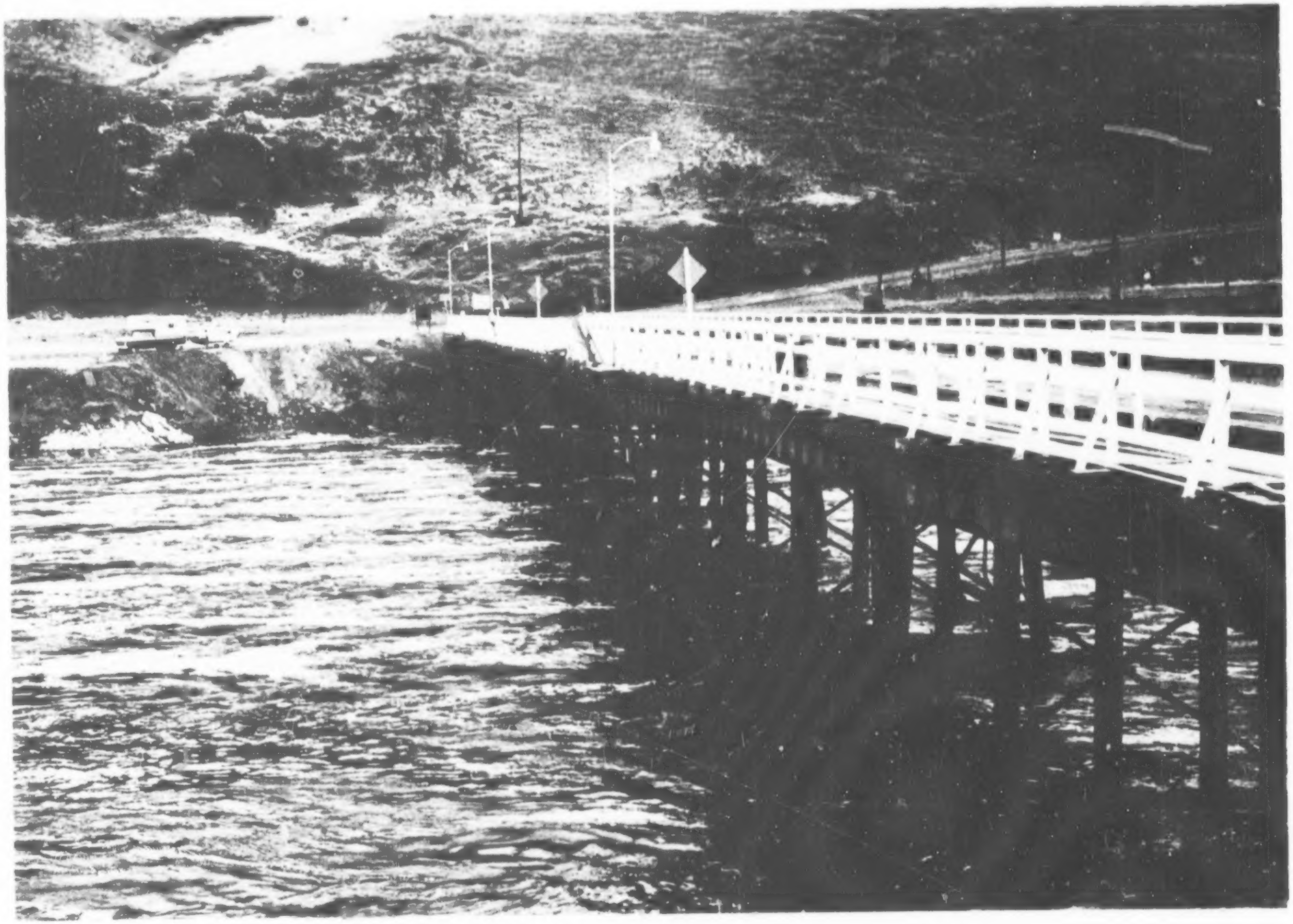
FIGURE 43 is a view of the existing FWPCA water quality instrument housing attached to the bridge just downstream of Oxbow Dam (barely visible in background). The bridge offers a practical location for a continuous recording thermograph due to the well mixed river condition at this point and easy site access. Vandalism is not considered to be a problem here because of its proximity to the dam. This water quality station has also been removed.



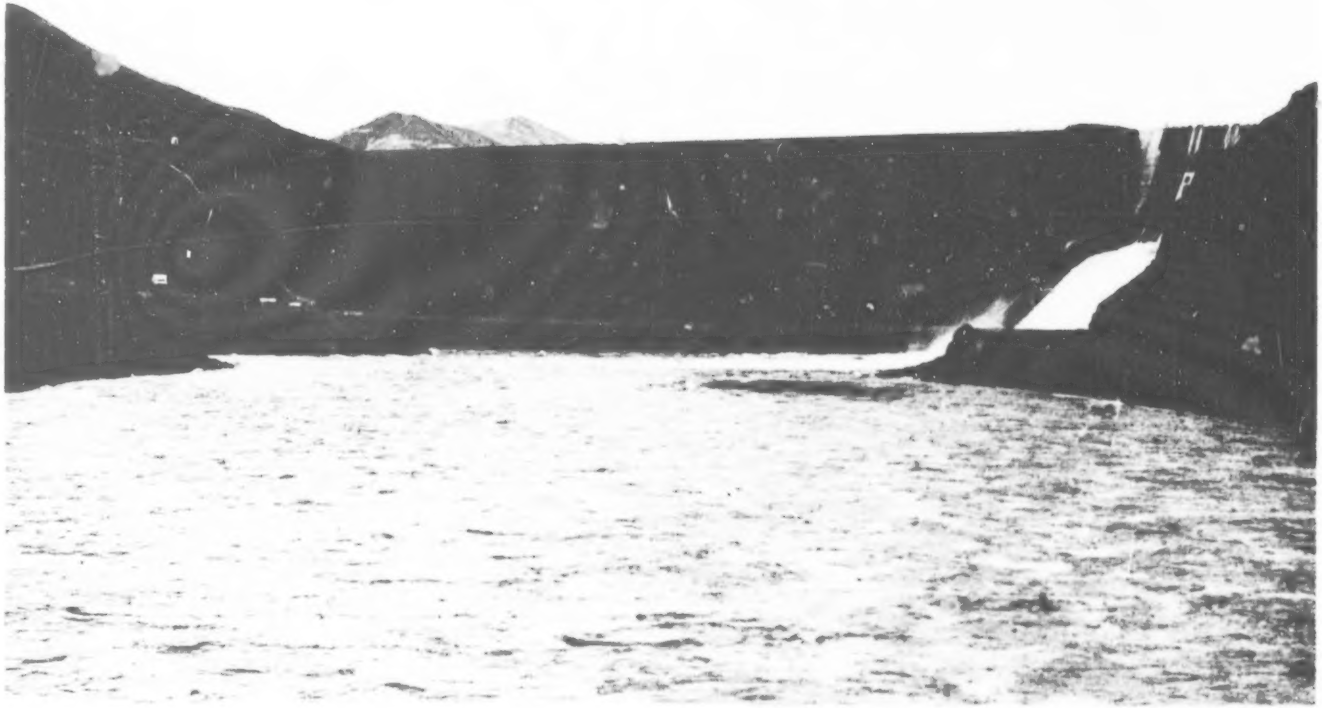
BRIDGE LOCATION ON THE SNAKE RIVER BELOW OXBOX DAM
Oxbow dam is just upstream around bend in the river
FIGURE 43

BROWNLEE DAM (Site No. 55)

A highway bridge just downstream of Brownlee Dam should be an adequate site for a continuous recording thermograph. As seen in the photograph of FIGURE 44, a platform exists below the bridge deck on the downstream side of the bridge. This platform would be a good location for a thermograph. Water passing this point is well mixed and vandalism potential would be minimal due to the site's proximity to Brownlee Dam (see FIGURE 45).



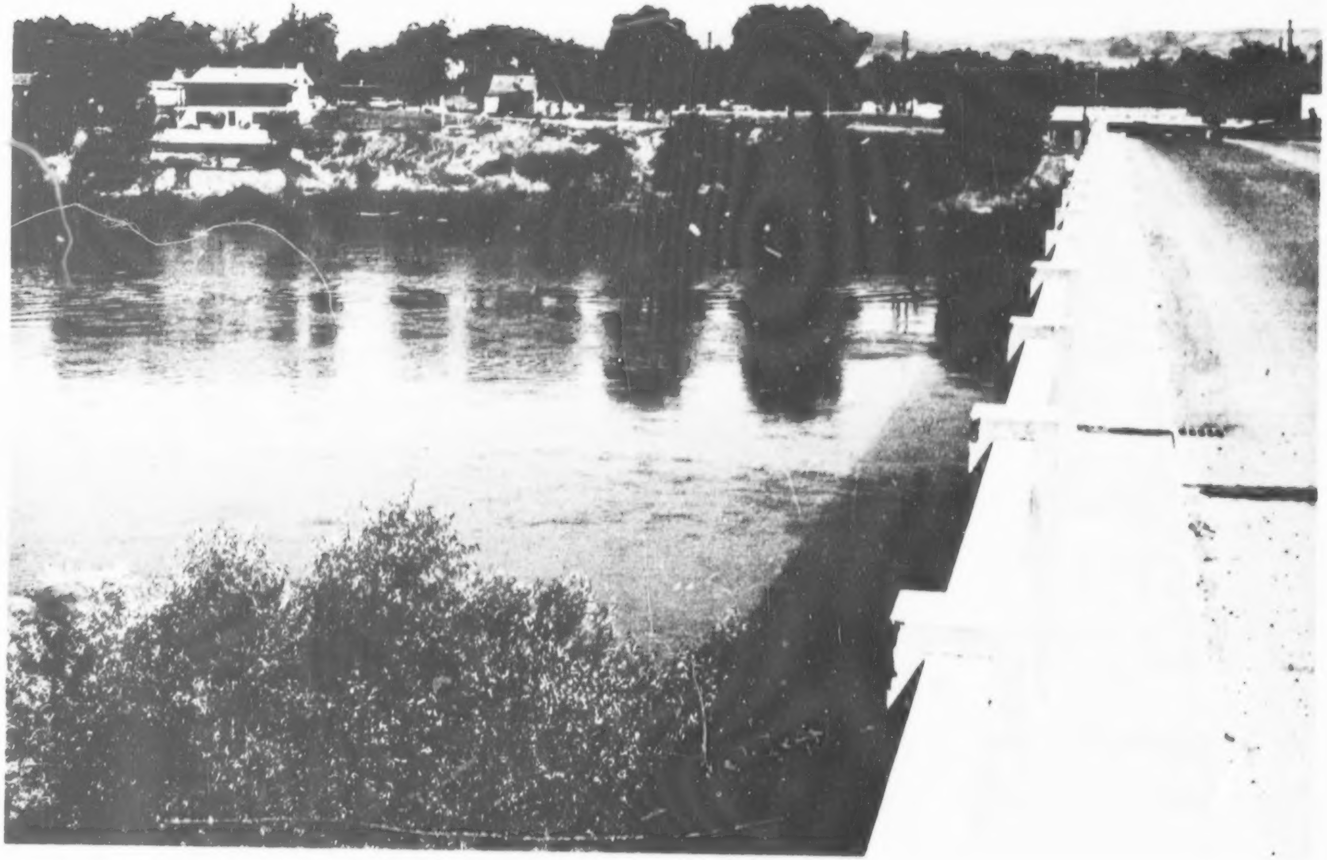
BRIDGE OVER SNAKE RIVER JUST DOWNSTREAM OF BROWNLEE DAM
FIGURE 44



BROWNLEE DAM
Looking at downstream face of Dam from bridge below Dam
FIGURE 45

WEISER SITE - SNAKE RIVER (Site No. 56)

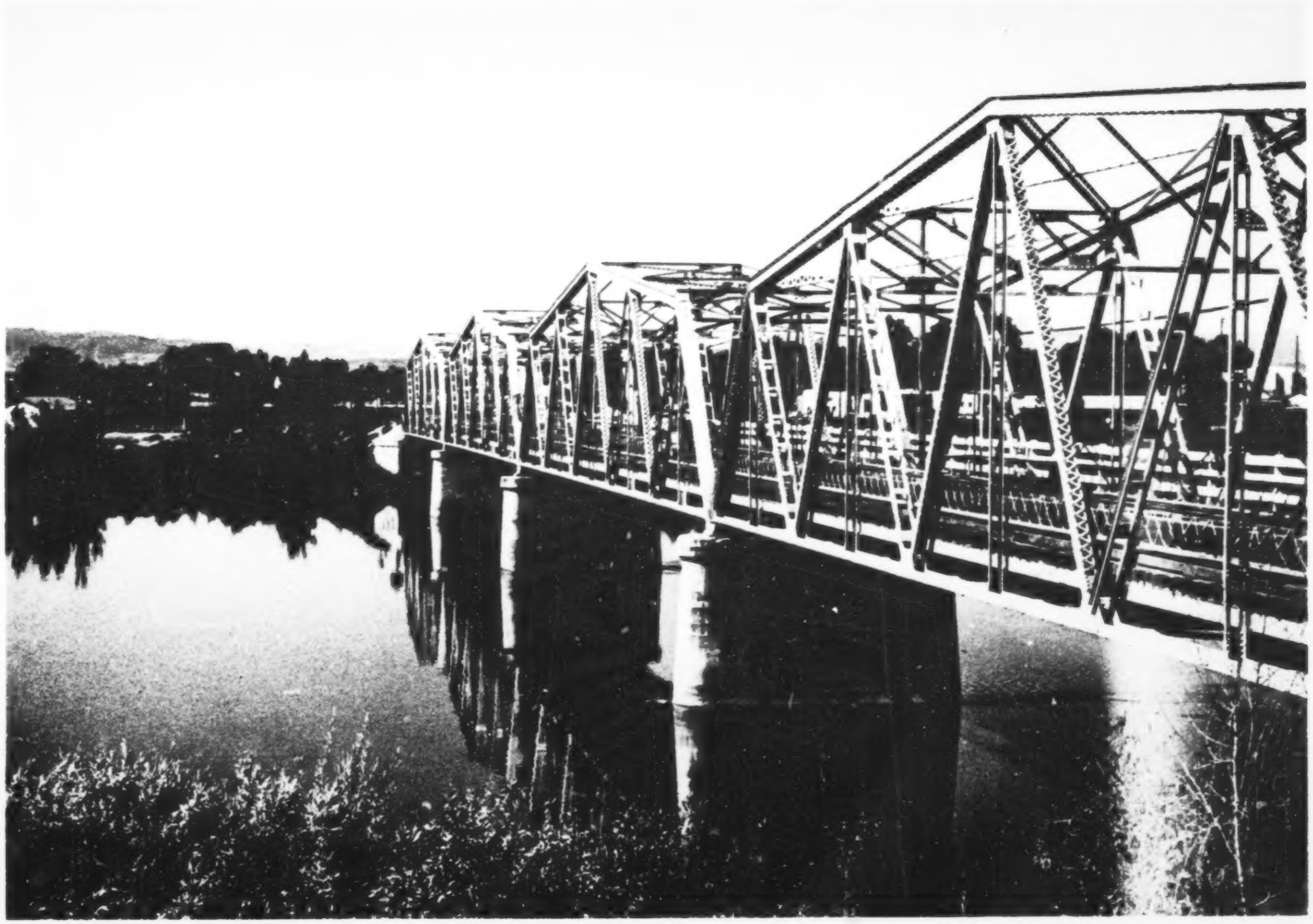
A possible thermograph location at Weiser, Idaho is approximately 0.5 miles downstream of the mouth of the Weiser River and is shown in FIGURE 46. The thermograph can be attached to the highway 30N bridge at Weiser, Idaho. Temperature cross-sections will be needed at this site before the thermograph is installed. Vandalism should not be much of a problem due to the heavy traffic over this main bridge.



SNAKE RIVER AT WEISER, IDAHO
Looking toward Idaho shore from Oregon shore at downstream side of Highway 30N bridge
FIGURE 46

SNAKE RIVER; OREGON-IDAHO BORDER (Site No. 60)

A thermograph site is needed on the Oregon-Idaho border of the Snake River to monitor temperature changes for "Water Quality Standards" purposes. Highway 19 bridge at Homedale, Idaho, shown on FIGURE 47, was investigated as a location for a continuous recording thermograph. Temperature cross-sections will have to be taken here prior to the installation of the recording instrument for insurance of a well mixed condition. Ample instrument protection against vandalism should be provided at this site.

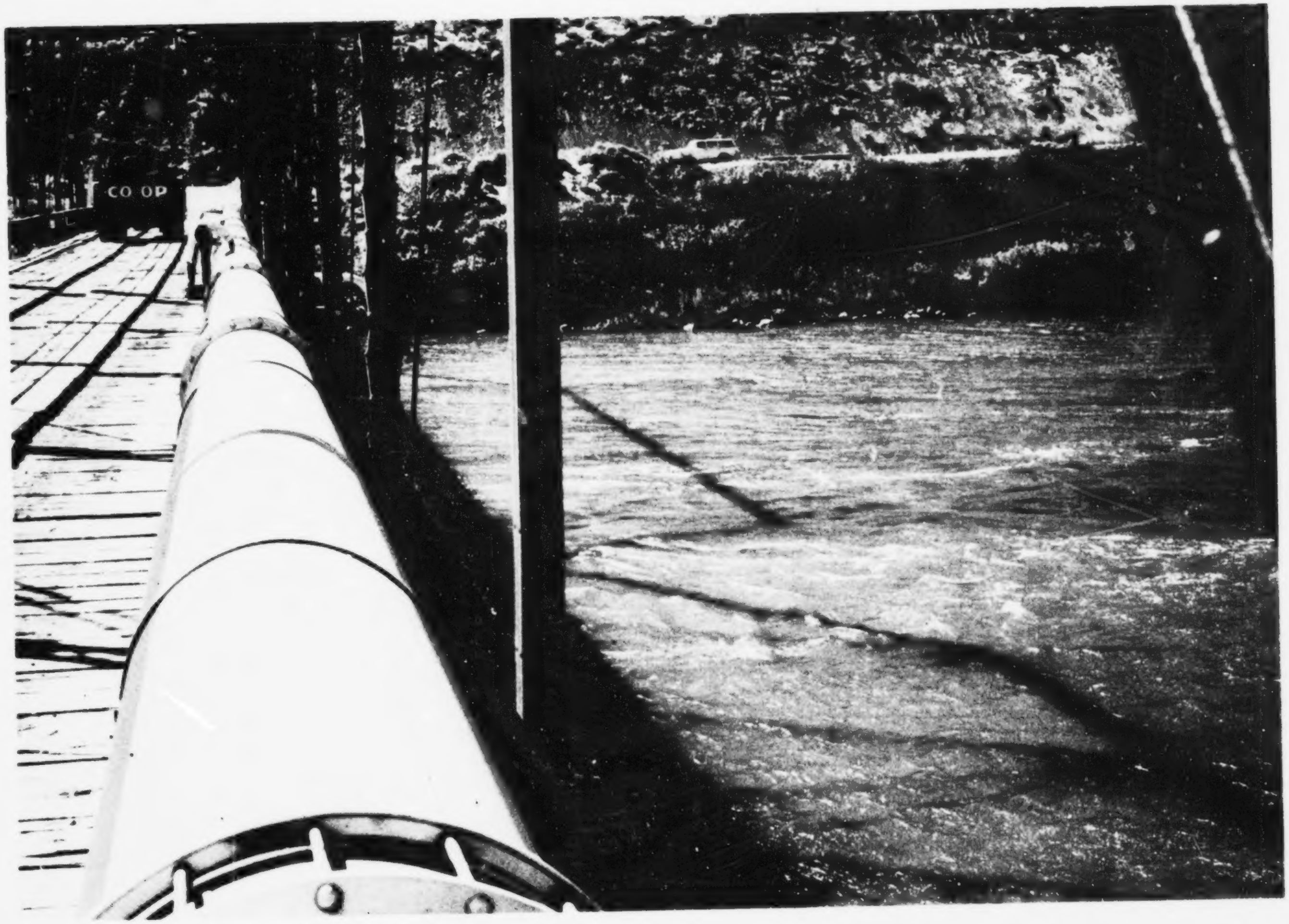


SNAKE RIVER AT HOMEDALE, IDAHO
Looking across the Snake River toward left bank upstream of highway No. 19 bridge
FIGURE 47

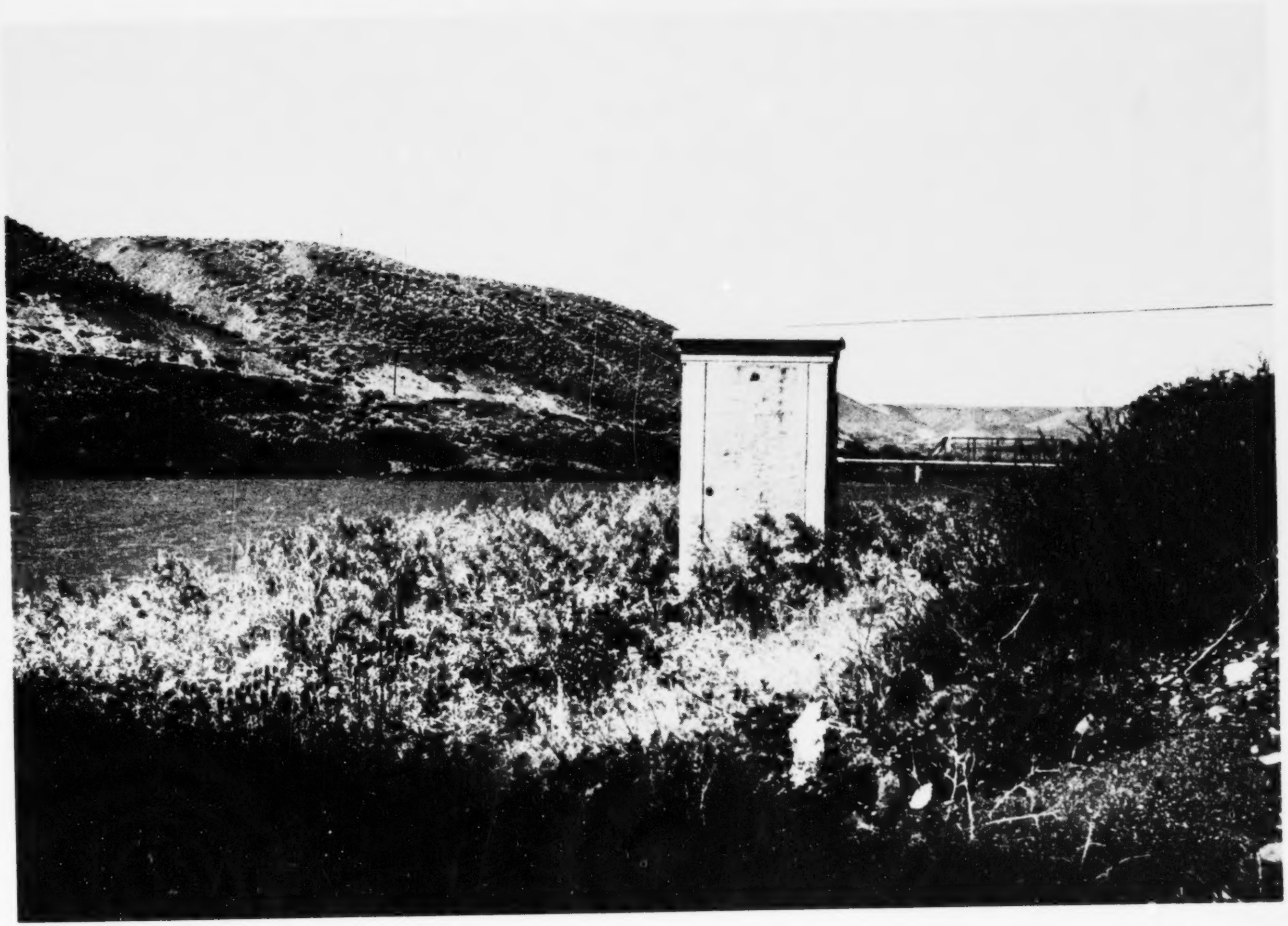
SNAKE RIVER - KING HILL, IDAHO (Site No. 61)

Temperature cross-sections were taken in the Snake River on August 28, 1968, at King Hill, Idaho. The results of these measurements showed that the Snake River at this point was completely mixed at 17.04 °C. The bridge shown in FIGURE 48, or the U.S.G.S. gaging station in FIGURE 49 are possible locations for a continuous recording thermograph.

The U.S.G.S. gaging station site would eliminate any vandalism, but the adaptation cost may be prohibitive. Protective housing would be required for the instrumentation at the bridge site which is in an isolated location.



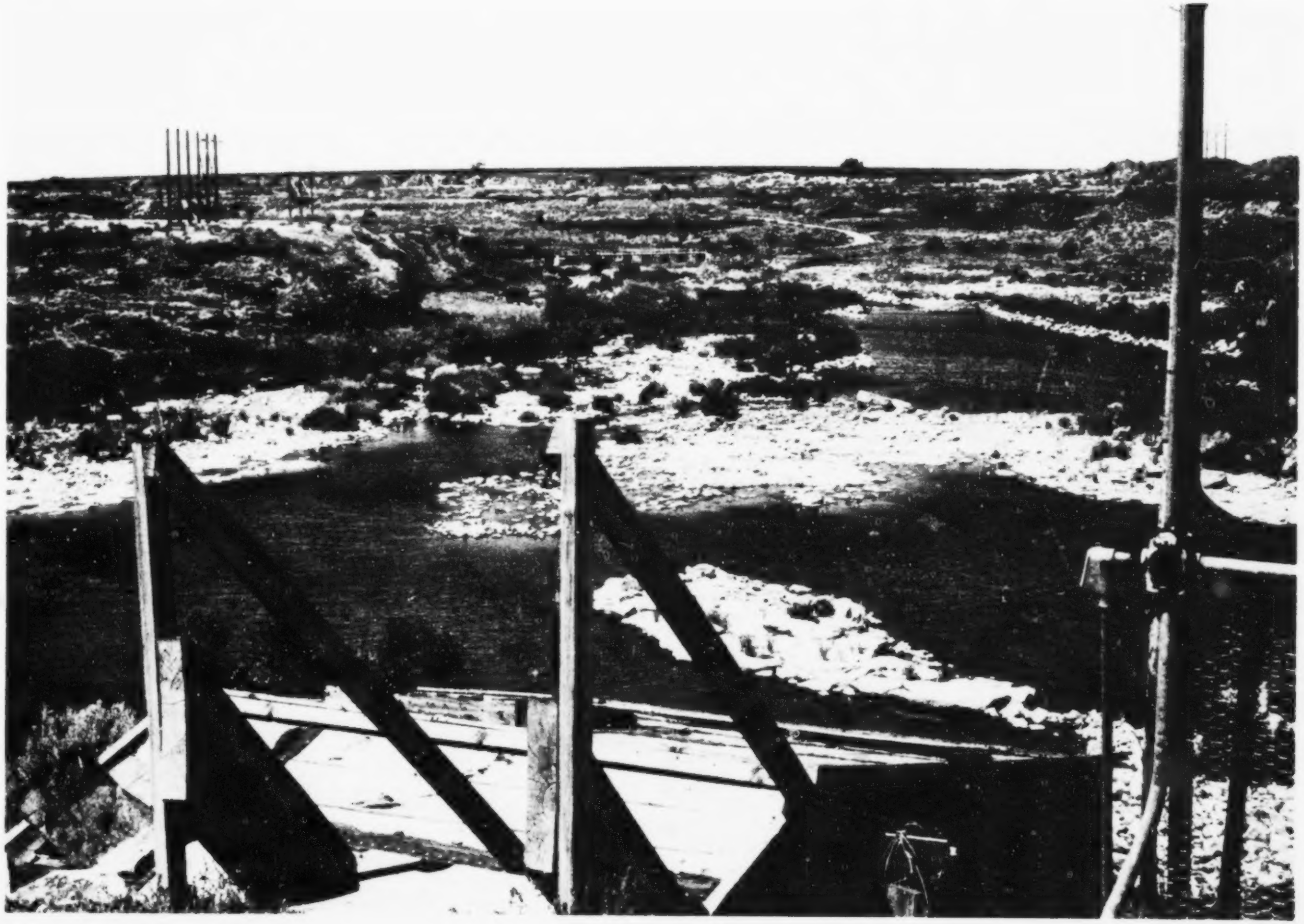
SNAKE RIVER AT KING HILL, IDAHO
Looking toward left bank at downstream side of bridge
FIGURE 48



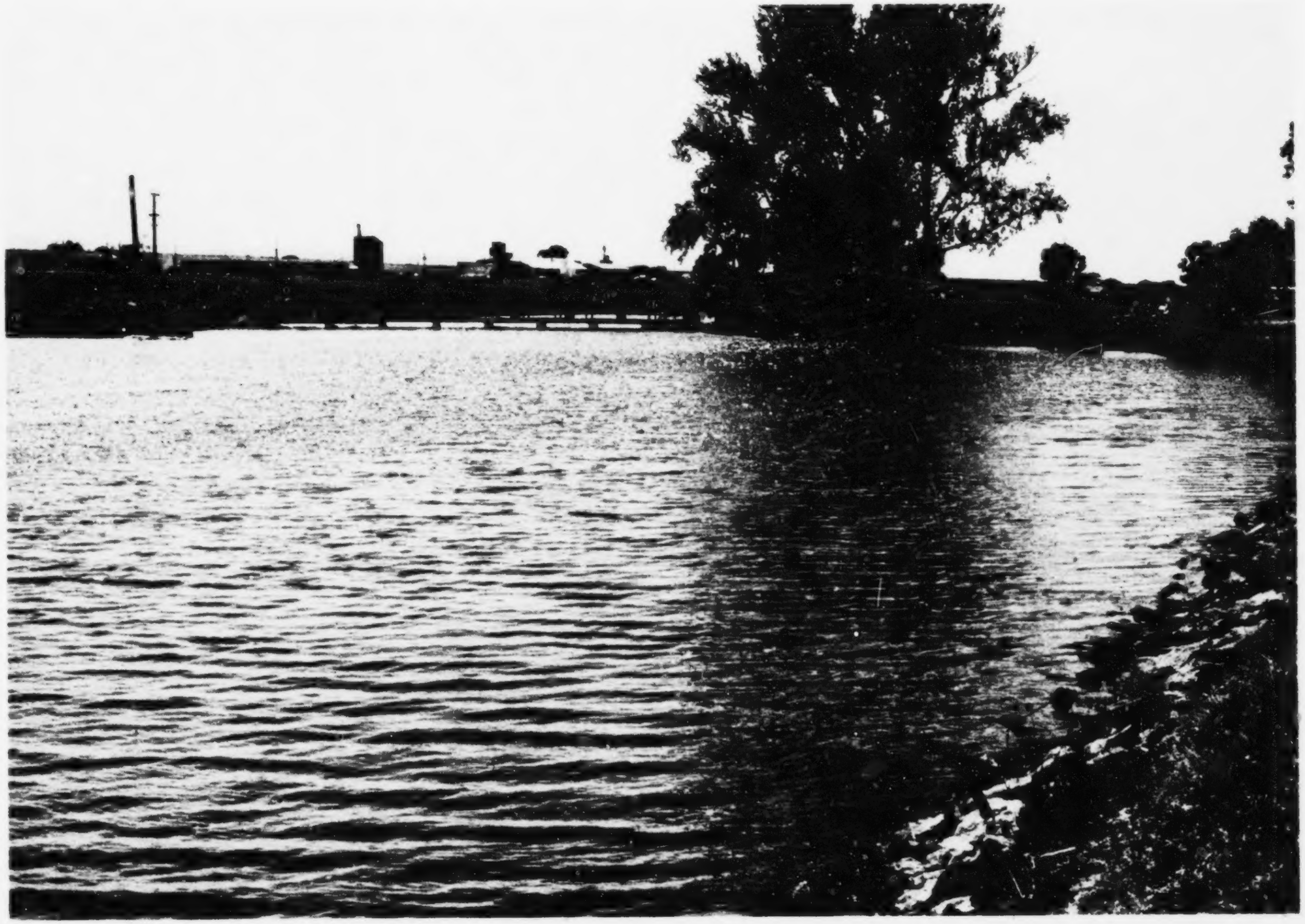
U.S.G.S. GAUGING STATION ON SNAKE RIVER AT KING HILL, IDAHO
Looking upstream at bridge with gauging station in foreground
FIGURE 49

MILNER DAM (Site No. 62)

Preliminary planning indicated that a thermograph location below Milner Dam should be included in the RTRN. Upon investigation of the site on August 28, 1968, it was discovered that the Twin Falls Canal Company had diverted the entire Snake River behind Milner Dam into several irrigation ditches. FIGURE 50 shows the condition downstream from Milner Dam and FIGURE 51 shows one of the irrigation canal diversions behind Milner Dam. Because the river is diverted during the irrigation season, a thermograph sensor downstream of the dam would be setting either in a stagnant pool or open air during part of the year, thereby yielding erroneous temperature results. Another site further downstream should be investigated, possibly in the "1000 Springs" area or the vicinity downstream of the irrigation waste water return flow.



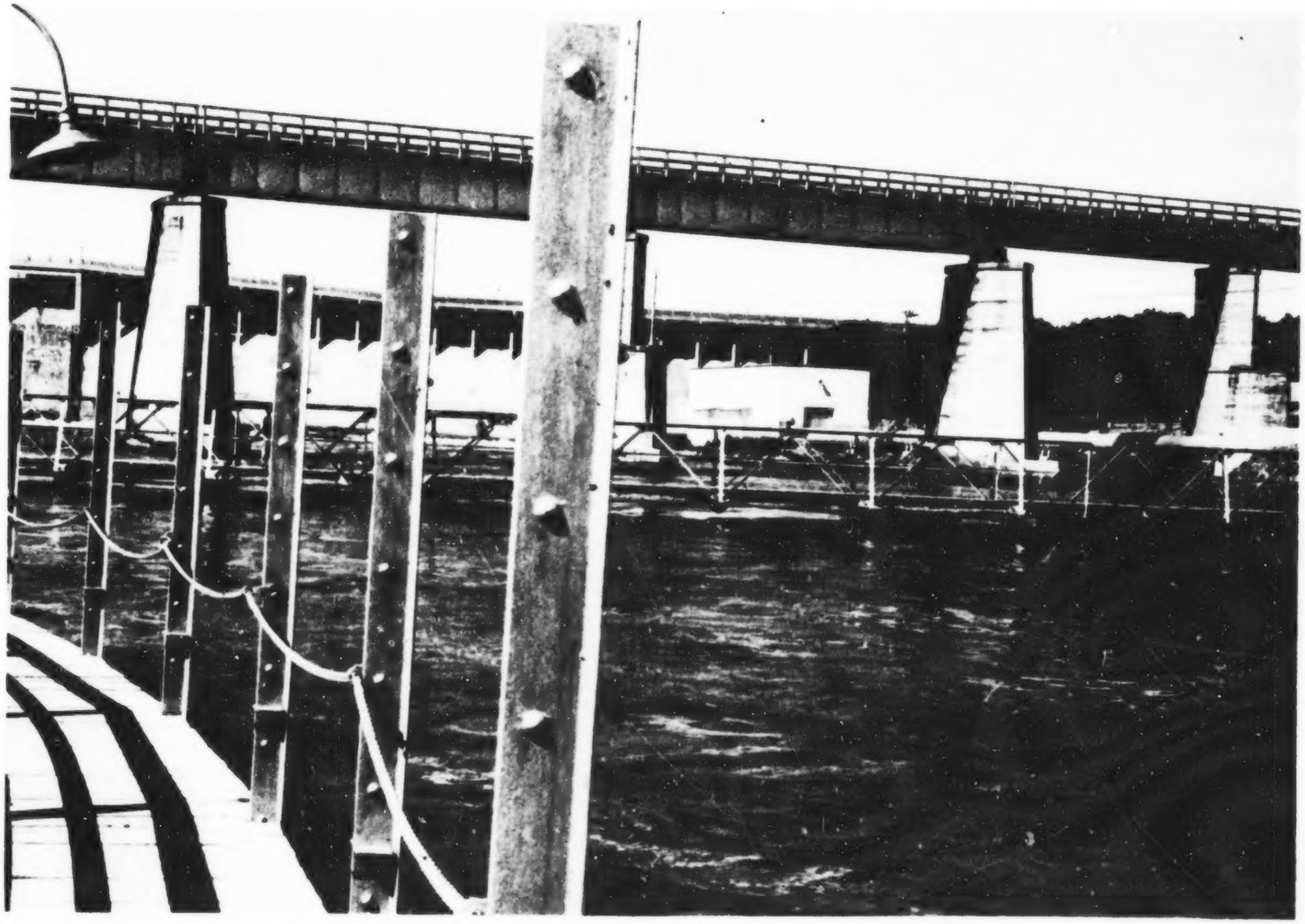
SNAKE RIVER JUST DOWNSTREAM OF MILNER DAM, IDAHO
Looking downstream from top of dam (flow completely shut off)
FIGURE 50



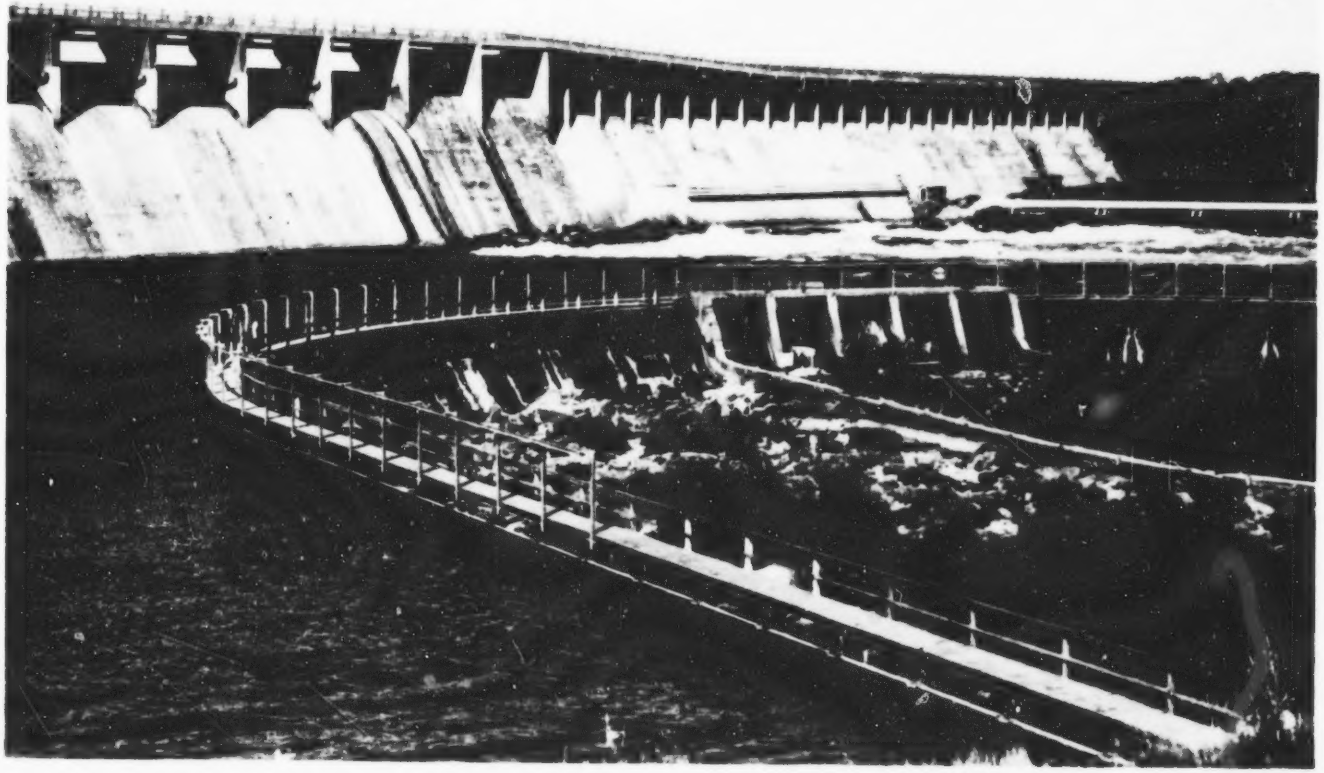
FOREBAY OF MILNER DAM
Looking across forebay at one of the main irrigation canals
FIGURE 51

AMERICAN FALLS DAM (Site No. 64)

A probable thermograph location below American Falls Dam is at the walkway across the left side of the secondary dam just downstream of the main dam and just upstream of the powerhouse as shown in FIGURE 52. During the low flow portion of the year, the river flow is discharged through conduits on the left side of the dam (FIGURE 53). This water is very turbulent (well mixed) as it passes the proposed thermograph location. Since this location is on the project, vandalism is considered to be minimal.



AMERICAN FALLS DAM ON THE SNAKE RIVER
Looking upstream from powerhouse toward footbridge (main Dam in background)
FIGURE 52



AMERICAN FALLS DAM ON THE SNAKE RIVER
Discharge is through conduits into secondary dam
FIGURE 53